UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	**Docket No. 63-001**
	)	
(High Level Waste Repository)	)	**December 19, 2008**

STATE OF NEVADA'S
PETITION TO INTERVENE AS A FULL PARTY

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GLOSSARY

ACNW	Advisory Committee on Nuclear Waste and Advisory Committee on Nuclear Waste and Materials
AEA	Atomic Energy Act of 1954, as amended, 42 U.S.C. §§ 2011, *et seq*.
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
AMR	Analysis Model Report
AOI	Additional Opportunity for Improvement
APA	Administrative Procedures Act, 5 U.S.C. §§ 551, *et seq*.
ASLB	Atomic Safety and Licensing Board
BLM	United States Department of Interior, Bureau of Land Management
BSC	Bechtel SAIC Company, LLC
BTP	Branch Technical Position
BWR	Boiling Water Reactor
CAP	Corrective Action Program
CAR	Corrective Action Report
CAQ	Condition Adverse to Quality
CEQ	Council on Environmental Quality
CNWRA	Center for Nuclear Waste Regulatory Analysis
CSNF	Commercial Spent Nuclear Fuel
CR	Condition Report
DBT	Design Basis Threat
DFN	Discrete Fracture Network
DOE	United States Department of Energy
DOI	United States Department of Interior
DPC	Dual-Purpose Canister
DR	Deficiency Report
DSRS	Document Storage and Retrieval System
EA	Environmental Assessment
EBS	Engineered Barrier System
ECP	Employee Concerns Program
ECRB	Enhanced Characterization of the Repository Block (the cross drift)
EIS	Environmental Impact Statement
EnPA	Energy Policy Act of 1992, 42 U.S.C. § 10141 note
EPA	United States Environmental Protection Agency
EPRI	Electric Power Research Institute
ESF	Exploratory Studies Facility
ESSE	Early Site Suitability Evaluation
FEIS	Final Environmental Impact Statement
FEP	Features, Events, and Processes
FOIA	Freedom of Information Act
FRN	Federal Register Notice
FY	Fiscal Year (10/01 through 9/30)
GAO	Government Accountability Office
GROA	Geologic Repository Operations Area

GWTT	Groundwater Travel Time
HLW	High-Level Radioactive Waste, including Spent Nuclear Fuel
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IG	Inspector General
INPO	Institute of Nuclear Power Operations
ISFSI	Independent Spent Fuel Storage Installation
ITS	Important to Safety
ITWI	Important to Waste Isolation
LA	License Application
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
LSS	Licensing Support System
LSN	Licensing Support Network
M&O	Management and Operating
MRS	Monitored Retrievable Storage Facility
NAS	National Research Council of the National Academy of Sciences
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4331, *et seq*.
Nevada	State of Nevada
NNWSI	Nevada Nuclear Waste Storage Investigation Project
NRC	United States Nuclear Regulatory Commission
NTS	Nevada Test Site
NWPA	Nuclear Waste Policy Act of 1982, as amended. Citations to the NWPA in this Petition are to the Public Law section rather than to the United States Code section. A copy of the NWPA as amended, with cross-references to Code sections (*e.g.*, NWPA § 113 codified at 42 U.S.C. § 10133; NWPA § 114 codified at 42 U.S.C. § 10134), included in the statutory/regulatory appendix filed with this petition
NWPAA	Nuclear Waste Policy Amendments Act of 1987, amending the NWPA
NWTRB	Nuclear Waste Technical Review Board
OCRWM	Office of Civilian Radioactive Waste Management
OIG	Office of Inspector General
OGC	Office of General Counsel
OMB	Office of Management and Budget
OQA	Office of Quality Assurance
ORISE	Oak Ridge Institute for Science and Education
OSR	On-Site Representative
PCSA	Pre-closure Safety Analysis
PMA	Performance Margin Analysis
PSHA	Probabilistic Seismic Hazard Analysis
PVHA	Probabilistic Volcanic Hazard Analysis
PWR	Pressurized Water Reactor
QA	Quality Assurance
QAMA	Quality Assurance Management Assessments

QAPD	Quality Assurance Program Description
QARD	Quality Assurance Requirements and Description
QC	Quality Control
RCRA	Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901, *et seq*.
RIT	Regulatory Integration Team
RMEI	Reasonably Maximally Exposed Individual
ROD	Record of Decision
SAIC	Science Applications International Corporation
SAR	Safety Analysis Report
SCC	Stress Corrosion Cracking
SCP	Site Characterization Plan, Department of Energy
SER	Safety Evaluation Report
SNF	Spent Nuclear Fuel
SNL	Sandia National Laboratory
SRCSD	Site Recommendation Comment Summary Document, United States Department of Energy, DOE/RW-0548, February 2002
SSC	Structure, System, or Component
SZ	Saturated Zone
TAD	Transportation, Aging, and Disposal Canister
TBM	Tunnel Boring Machine
TBR	Technical Basis Report
TEV	Transport and Emplacement Vehicle
TPA	Total-System Performance Assessment (NRC)
TRW	TRW Environmental Safety Systems
TSPA	Total System Performance Assessment for DOE
TSPA-LA	Total System Performance Assessment for DOE License Application
TSPA-SR	Total System Performance Assessment for DOE Site Recommendation
TSPA-VA	Total System Performance Assessment for DOE Viability Assessment
USAF	United States Air Force
USGS	United States Geological Survey
UZ	Unsaturated Zone
VA	Viability Assessment
WP	Waste Package
YMDA	Yucca Mountain Development Act, Pub. L. 107-200; 107th Cong., 2d Sess, 116 Stat. 735
YMP	Yucca Mountain Project
YMPO	Yucca Mountain Project Office
YMRP	Yucca Mountain Review Plan, NUREG-1804

I. **INTRODUCTION**

A. **Request and Party Identity**

The State of Nevada (Nevada) hereby petitions for a formal hearing to be held on the application of the Department of Energy (DOE) for a construction authorization for the proposed high-level radioactive waste repository at Yucca Mountain (hereinafter referred to as the "proceeding"). Nevada also petitions to intervene as a full party to this proceeding. The name of the party and its addresses (and related contact information) are as follows:

Name of party: Nevada

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Carson City, Nevada 89701
Tel: 775-684-1237
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The Office identified below should also be kept informed:

State of Nevada
Office of the Governor
Agency for Nuclear Projects
Nuclear Waste Project Office
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Carson City, NV 89706-7954
Tel: 775.687.3744
Email: nwpo@nuc.state.nv.us

B. **Timeliness**

The application was noticed for hearing on October 22, 2008 (73 Fed. Reg. 63029, 10/22/2008), and this Petition is timely filed within 60 days of publication of such notice.

C. **Standing**

1. The proposed repository would be located about 90 miles from the city of Las Vegas, Nevada, within the State of Nevada. Therefore, Nevada is entitled to request a hearing and to be admitted as a full party to the proceeding pursuant to 10 C.F.R. §§ 2.309(d)(2)(iii) and 63.63(a), and section III, paragraph A of the Notice of Hearing.

2. In addition to this provision, Nevada has standing to request a hearing and to intervene because (a) it would suffer numerous concrete and specific injuries in fact, within the zone of interests protected by the NWPA, the AEA, and the NEPA, should Yucca Mountain be licensed, (b) these injuries can fairly and directly be traced to the challenged action, i.e., the issuance of the construction authorization by the NRC, and consequent transportation to, and disposal of waste at, Yucca Mountain, and (c) these injuries will be redressed by denial of DOE's application. These injuries are described fully in the affidavit by Robert R. Loux, the Executive Director of the Nevada Agency for Nuclear Projects attached as Attachment 1.

(a) Injuries in Fact and Causation

The Loux affidavit explains that Nevada has a strong interest in protecting the health and safety of its citizens from radiological injuries and in protecting its lands and groundwater from radioactive contamination. Among other injuries, the disposal of radioactive waste at Yucca Mountain will inevitably lead to increased radiation doses to Nevada's citizens and to the contamination of the lands and the groundwater of Nevada with radioactive materials. Nevada's sovereign interests are injured because, under Nevada law, all groundwaters are owned by the people of Nevada and administered in trust by Nevada. These injuries will be avoided if DOE's application is denied, the precise relief requested herein by Nevada. These radiological injuries are sufficient to give Nevada standing to intervene. *See Private Fuel Storage L.L.C.*

(Independent Spent Fuel Storage Litigation), CLI-98-13, 48 NRC 26, 33 (1998); *Sequoyah Fuels Corporation (Gore, Oklahoma Site Decommissioning)*, LBP-99-46, 50 NRC 386, 395 (1999).

(b) Zone of Interests

Nevada's stated injuries are radiological in nature, and therefore, they fall within the zone of interests protected by the NWPA, the AEA, and the NEPA.

(c) Redressibility

These injuries will not occur if the Yucca Mountain application in this proceeding is denied, the relief requested by Nevada.

D. **Hearing Requested**

Nevada requests a formal adjudicatory hearing on each of its contentions in accordance with section 189a(1)(A) of the Atomic Energy Act of 1954, as amended, section 114(d) of the Nuclear Waste Policy Act of 1982, as amended, 5 U.S.C. §§ 554-558, and 10 C.F.R. Part 2, Subparts C, G, and J. In addition, Nevada asks to participate in the resolution of uncontested issues to the same extent, and in the same manner, as DOE or any other party may be allowed to participate in the resolution of those issues.

E. **Subpart J**

Nevada has substantially and timely complied with the provisions of Subpart J, including Section 2.1003 and Section 2.1009, in that it has designated an official responsible for administration of its responsibility to provide electronic files of Documentary Material; established procedures to implement the requirements of Section 2.1003; provided training to its staff on the procedures for implementation of the responsibility to provide electronic files of Documentary Material; has expended substantial time and good faith effort to ensure that it has made all its Documentary Material publicly available; and its responsible designated official has certified that to the best of his knowledge, the Documentary Material specified in Section 2.1003 has been identified and made electronically available.

Nevada submitted an adequate and timely initial LSN certification (on January 17, 2008), and adequate and timely supplemental certifications (on February 2, 2008, February 26, 2008, March 31, 2008, April 28, 2008, May 30, 2008, June 27, 2008, July 30, 2008, August 29, 2008, September 29, 2008, October 30, 2008, and November 25, 2008). Moreover, Nevada participated fully in all pre-application phases of this proceeding before two licensing boards and the Commission. Therefore, Nevada has complied fully with the provisions of section II, paragraphs 2, 3, and 7 of the Notice of Hearing, there is no "failure . . . to participate as a potential party in the pre-License Application phase under Subpart J of [10 C.F.R. Part 2]," and correspondingly, there is no basis for limiting or denying full party status to Nevada under 10 C.F.R. § 2.309(a).

F. **Joint Contentions**

At this time, Nevada has no joint contentions. Nevada may identify joint contentions later, in accordance with such reasonable schedule as may be set by the presiding officer.

II. **INTRODUCTION TO CONTENTIONS**

Pursuant to the Pre-License Application Presiding Officer Board's June 20, 2008 Memorandum and Order (LBP-08-10), Nevada drafted "single-issue" contentions, each raising a single safety, environmental (NEPA), or legal issue and supported by a single set of related facts or omissions. However, because it may be difficult to discern the overall themes in Nevada's case against Yucca Mountain from individual contentions, we have prepared this introduction. It is not intended to be any part of any contention within the meaning of 10 C.F.R. § 2.309(f). In addition, some contentions are omitted from this summary in the interest of brevity.

SAFETY

Programmatic:

Nearly all of Nevada's contentions challenge DOE's claim that disposal of high-level radioactive wastes and spent nuclear reactor fuel at Yucca Mountain will be safe – that is, DOE's claim that disposal will comply with federally prescribed standards for radiation dose to the public.[1] Several safety contentions challenge DOE's fitness as a potential NRC licensee, the entity with direct and primary responsibility to protect the public health and safety. DOE does not have the necessary safety culture and competence to be an NRC licensee for a complex, first-of-a-kind project like Yucca Mountain that involves inherently dangerous technology. DOE fostered a management culture which attached higher priority to meeting artificial schedules than compliance with safety rules and withheld important safety information from the license application. DOE's historic inability to implement an adequate quality assurance (QA) program for the Yucca Mountain Project, despite numerous promised "get-well" plans, means that its commitments regarding its QA program for the duration of the Project cannot be relied on.

Post-Closure Safety:

Most of Nevada's safety contentions address DOE's "post-closure" safety case. DOE's LA asks the NRC to allow DOE to dispose of seventy thousand metric tons (heavy metal) of high-level radioactive wastes and highly radioactive spent nuclear reactor fuel in Yucca Mountain. The disposal is intended to be permanent – Yucca Mountain is not proposed as a "storage" facility as it is sometimes portrayed. The post-closure safety case is the part of the LA

[1] Because there is no final NRC regulation that applies to the post-10,000 year post-closure performance assessment, Nevada's contentions on this subject focus on the EPA's October 15, 2008 final rule (73 Fed. Reg. 61256). NRC's and EPA's radiation standards rules for the assessment period before then are identical (a probability weighted 15 mrem per year).

in which DOE attempts to prove that permanent disposal of these very hazardous and long-lived materials at Yucca Mountain will be "safe."

Clearly, deficiencies in DOE's post-closure safety case are of central importance to Nevada and its citizens. DOE's Total System Performance Assessment ("TSPA"), required by EPA and NRC regulations (40 C.F.R. § 197.20 and 10 C.F.R. § 63.102 (j)), is the heart of DOE's post-closure safety case. The TSPA is an extremely complicated, non-linear collection of linked mathematical models that are supposed to simulate repository radioactive releases into the distant future. DOE uses one or an array of linked computers to implement the collection of TSPA models and to calculate releases of radioactive materials and annual doses to an EPA-defined Reasonable Maximally Exposed Individual (RMEI) in the accessible environment 18 km (11 miles) from Yucca Mountain. There are numerous computer "runs" whereby DOE effectively rolls the dice to select the relevant parameter values used as inputs to the calculation, using the particular parameter value probability distributions that DOE selected on ill-defined and often apparently arbitrary bases. Each "run" produces a specific radiation dose time history.

DOE has done a very a poor job of gathering scientific data, and some of DOE's critically important models cannot be validated with data that have been collected. DOE assigns a probability distribution to hundreds of scientific parameters, when data are available, so that each computer "run" of its TSPA model collection can "sample" from assigned parameter values. However, there is no apparent logic to how the shapes of the various distributions of data (or probability density functions) were selected. Sometimes data are so sparse that a supposedly "bounding" high estimate and a low estimate are all that is available, but DOE assumes arbitrarily that all values in between are equally likely.

DOE ran the overall TSPA calculation many hundreds of times for each calculation case in an effort to assure that its calculations of the expected annual doses are statistically valid. The EPA standards apply to the mean, or average, of these runs. The collection of "runs" for one case are illustrated in the "horsetails" in Figure 2.4-10 on page 2.4-424 of the SAR. The TSPA is so complex that a single run of the many hundreds needed for statistical validity typically requires one to two hours to complete on a top-of-the-range PC. The TSPA overall model is nearly inscrutable, even to experts, and the enormous requirement in terms of computing resources means that it is virtually impossible for the calculations undertaken by DOE to be duplicated and verified by other parties.

As indicated above, because DOE lacked necessary scientific data, it was unable to adequately validate all of the individual model components of the TSPA. DOE also has ignored or improperly analyzed certain system and design "features," numerous physical "events," and various physical and chemical "processes," collectively called "FEPs." Perhaps the most glaring instance is DOE's failure to even consider the possibility that the more than 11,000 drip shields, each composed of five tons of expensive titanium alloy, which DOE asks us to believe someone will install 100 years in the future, will not in fact be installed. It is a crucial omission as DOE's own TSPA calculations show it cannot comply with federal dose standards without the drip shields.

Although Yucca Mountain is supposed to be a "geologic" repository, the most important feature delaying the movement of radioactive materials to the accessible environment is this collection of titanium alloy drip shields, an engineered barrier. The project is far removed from its original concept as a "geologic repository." The original concept of a "geologic repository" was that good geology (here, the mountain) would protect humans from the radioactive waste;

now an engineered barrier is needed to protect the radioactive waste from the mountain. DOE added the drip shields to its design when it discovered that Yucca Mountain's geology provided a poor barrier to the flow of water from the surface to the drifts (tunnels) in which the waste containers would be emplaced. The subject title of an internal Project e-mail, "Water Water Everywhere," addresses the discovery of water in the underground tunnels and captures the essence of the problem (e-mail L. Rickertsen to E. Taylor (4/1/1998), LSN# DN2000615084 at 1). Indeed, the DOE term "drip shield" indicates unmistakably that water is a serious problem.

If the drip shields fail earlier than DOE says they will, or if they are improperly installed or not installed at all, there is no backup, no defense-in-depth, to prevent violation of the EPA standard. In fact, an analysis based upon DOE's early drip shield failure scenario indicates that the EPA dose standard is violated within 1,000 years after closure if there are no drip shields.

Quite apart from the physical difficulty of installing drip shields a 100 years from now, it is unreasonable to rely on DOE's promise to do so as it is meaningless and unenforceable. DOE is in no position to commit Congressional expenditures of many billions of dollars so far in the future. But the physical difficulties make such an installation even more unlikely. It requires near perfect fabrication and *remote* installation of the drip shields in the tunnels. That requires smooth deep underground operation of robotic installation equipment despite high temperatures exceeding the boiling point of water, dust, poor visibility, close tolerances, high radiation fields, and potential debris from rockfalls. DOE has no real plans and designs for the installation, and relies on the use of future machines and equipment that have never been fabricated even as prototypes, nor does DOE have plans for such prototypes.

Most remarkable, and downright scary, is DOE's plan to install the drip shields about one-hundred years from now, <u>after</u> wastes are emplaced in the tunnels. If installation proves to be defective or impossible, it will be too late to assure safety by alternative methods short of the complex and hazardous task of retrieving the wastes from the tunnels. And by the way, DOE has not provided us with any actual retrieval plans or any articulation of the circumstances under which retrieval may be undertaken.

DOE also chose what it thought would be a corrosion-resistant metal, alloy 22, for the waste container surface, although there was no experience with this metal in Yucca Mountain's corrosive environment, nor with exposures for many thousands of years. DOE adopted the strategy of relying on engineered barriers (the drip shields and waste packages) notwithstanding the advice of one of its experts that "[i]t is ridiculous to completely rely on engineered barriers, the lifespan of which has never been tested for even 10s or 100s of years. . . ." (this quote is from an internal DOE e-mail from Bob Levich to Paul Dixon (9/24/1997), LSN# DN2001816925 at 1). DOE makes unprecedented extrapolations from limited (and sometimes also inapplicable) corrosion studies, ignores troublesome modes of corrosion, and uses oversimplified and unsupported models of coupled thermal, hydrological, and chemical interactions among natural and engineered features. On this score DOE rejected advice regarding the TSPA from its statutory advisory committee, the NWTRB.

DOE also systematically underestimates uncertainty by ignoring the mandatory requirement to propagate through the safety assessment how Yucca Mountain might perform in isolating wastes using scientifically supported alternative models. It is a serious failing because, given the uncertainty of the models, only if alternative models produce comparable results can one have any confidence in the outcome.

In all, Nevada has over 150 safety contentions attacking DOE's TSPA or the conceptual models and data on which it relies. Each contention focuses on cited portions of DOE's LA, cites to applicable NRC requirements that are violated, and is supported by an expert analysis (paragraph five of each contention). They show, among other things, that:

- DOE's selection of which FEPs to include in the TSPA, an essential early step, ignores important events and processes and improperly excludes others. DOE's inability to install drip shields, and problems in installing them properly, discussed above, are examples. Also, a scientific study shows that within the assessment period prescribed by EPA natural processes may erode Yucca Mountain down to the level of the emplacement tunnels, completely exposing the wastes. DOE refuses to consider this in its TSPA;
- DOE's selection of future climate states to predict precipitation on Yucca Mountain surfaces cannot be justified;
- DOE's new MASSIF net infiltration model, used to estimate infiltration of water from the mountain surfaces to near the repository tunnels, has over a dozen fatal flaws that render it completely invalid;
- DOE's model to estimate seepage into the tunnels is invalid because it ignores the interplay of applicable diffusive, advective, heat and mass transfer processes, coupled with phase transitions;
- DOE concedes that the drip shields and waste packages will eventually corrode from seepage and other sources, but its models to predict corrosion rest on data that are inapplicable and ignore demonstrated processes that would greatly increase amounts and rates of corrosion;
- DOE does not demonstrate that its plans to install drip shields are feasible and its assumption of near-perfect drip shield installation is not justified;
- DOE's plan to install the drip shields about one-hundred years from now, after wastes are emplaced in the tunnels, cannot be justified because if installation proves to be defective or impossible, it will be too late to assure safety by alternative methods;
- DOE's model for estimating the movement of radioactive materials from below the repository to the accessible environment assumes a degree of adsorption of radioactive materials that is not justified by data;
- DOE's calculation of how radioactive materials reaching the accessible environment will result in doses to humans is wrong and is based on misuse of the available data;
- DOE systematically underestimates uncertainty when it ignores alternative models of how Yucca Mountain might perform in isolating wastes, and does calculations using only a small number of scenario classes combined with only a somewhat larger number of modeling cases; and
- If the wastes are retrieved, they must be stored thereafter at Yucca Mountain because DOE does not articulate any other storage alternative. Therefore, it

> appears that DOE's fundamental objective is to move the wastes to the Yucca Mountain site in Nevada and keep them there, regardless whether disposal there is safe.

In particular, the contentions relating to the post-closure safety assessment, as implemented in the TSPA, demonstrate that the infiltration of water into Yucca Mountain has not been properly estimated, that the flow of that water through the unsaturated zone above the repository has not been appropriately represented and that its chemical characteristics have not been suitably characterized. Furthermore, the potential for unsaturated zone water to enter the emplacement drifts has been underestimated, because of fundamental conceptual errors in the modeling and because of neglect of the effects of components of the rock support system on water entry. The potential for corrosion and mechanical degradation of both the drip shields and waste packages has been seriously underestimated, due to reliance on inappropriate experiments and the neglect of various modes of corrosion and mechanical degradation. Taken together, these various contentions indicate that releases of radionuclides will be much larger and occur much earlier than has been assessed by DOE. This necessarily means that the radiological impacts of the repository have been substantially underestimated. In addition, whole areas of relevant science have been excluded from consideration, *e.g.* greenhouse-gas induced climate change and the lowering of the topography of Yucca Mountain by erosion. Also, though great reliance is placed by DOE on the claimed long-term integrity of the proposed engineered barrier system, the design and operation of that system are so scantly described that there can be no assurance that it will meet even the inadequate specifications proposed by DOE or that all its components can ever be installed.

Nevada's post-closure TSPA contentions make, in the aggregate, two overarching safety claims. First, DOE has not proved that its TSPA accurately models the performance of the natural geologic barriers and the installed engineered features of Yucca Mountain over the assessment period prescribed by EPA. Second, given the limited data that are provided about future plans and designs, and what appear to be serious technical obstacles, there is no assurance that DOE's plans for the repository, especially its doubtful plans to install drip shields, meet federal dose standards.

Pre-Closure Safety:

Pre-closure safety generally addresses safety of workers and the public during repository operations and the conduct of other activities prior to permanent closure. Nevada's contentions here include a failure to protect against terrorist attacks such as occurred on 9-11, an insufficient evaluation of means to reduce radioactive doses to workers at the site, and an elimination of aircraft crashes from the safety design bases based on faulty statistics and unwarranted assumptions about future U.S. Air Force flight restrictions. DOE also fails to provide an emergency plan or even a description of such a plan, opting instead to continually parrot back the regulatory requirement with a mere commitment to develop something in the future.

NEPA

Nevada's NEPA contentions include DOE's inadequate evaluation of impacts from transportation of high-level radioactive wastes and spent reactor fuel from sites around the country to Yucca Mountain. This is of special concern to Nevada because large quantities of spent reactor fuel will be transported through heavily populated downtown Las Vegas, near Las Vegas Boulevard in the heart of the gaming district and close by over 40,000 hotel rooms. The safety record of transportation of nuclear materials in the United States has been very good, but DOE proposes a transportation campaign that dwarfs anything done before, both in terms of the huge amount of nuclear waste to be shipped and the large number of shipments to be made.

Moreover, terrorism is a relatively new and continuing concern, and a single well-planned and executed attack on a single cask of spent reactor fuel could have grave safety and economic consequences. As limited options are proposed for routing of waste packages through Nevada, focusing of terrorist activities on those routes is a particular concern of the state.

There are other notable NEPA contentions, including NRC Staff's remarkable proposal to adopt virtually all of DOE's several Yucca Mountain environmental impact statements while, at the same time, refusing to state whether it actually agrees with everything in them. As various aspects of these environmental impact statements have been found to be incorrect, incomplete, or inadequate, as set out in the contentions, it cannot be appropriate for the NRC Staff to adopt them.

MISCELLANEOUS

This category includes several "legal" contentions. For example, DOE's proposed "aging pad" is a disguised "Monitored Retrievable Storage Facility" that clearly violates the NWPA. Moreover, because natural processes will eventually erode Yucca Mountain down to the level of the repository drifts, exposing the waste packages to the atmosphere while the wastes within them are still dangerous, Yucca Mountain cannot satisfy the mandate Congress had in mind when it only authorized DOE to apply for a license for "permanent deep geologic disposal."

ORGANIZATION AND CITATION

Finally, a few words should be added about organization of the contentions and citations within them.

Safety contentions are first, and within this category, a few contentions addressing DOE as the potential licensee are first, followed by contentions addressing post-closure safety (especially the TSPA), and then contentions addressing pre-closure safety. NEPA contentions are next, followed by a few contentions in the "miscellaneous" category.

Because there are so many TSPA contentions, descriptive subtitles are added to describe groups of TSPA contentions addressing a similar subject (for example, corrosion). These subtitles are not intended to be a part of the contentions themselves, and they may be somewhat inexact, but they should be helpful to the reader.

Nevada also designates some contentions as "legal" contentions or as contentions alleging an error of omission. When applicable, these designations appear in the first paragraph of the contention. Legal contentions question the lawfulness of what DOE proposes (such as whether Yucca Mountain is even a geologic repository authorized by the NWPA). They are framed based on factual premises that are usually apparent from the LA itself, and most should be resolvable based on written briefs and oral argument. There are some rule challenges, requiring a special certification to the Commission (10 C.F.R. § 2.335), but these are not designated as "legal" contentions because they are predominantly safety in nature. Errors of omission are contentions that are based on the complete absence of a necessary document (for example, an emergency plan or retrieval plan). We do not designate every inadequacy in the LA as an error of omission even when the error might be corrected by adding something because doing so would result in hundreds of such designations, greatly diminishing the utility of the designation.

The references in the contentions are to DOE’s LA or NEPA documents, to available legal or technical materials, or to materials (affidavits) that are attached (each affidavit identifies the particular contentions whose supporting information is sponsored by the affiant). Most citations are to materials on the LSN. If, contrary to expectation, a document cited by Nevada cannot be located easily, Nevada would be pleased to provide assistance in locating it promptly.

III. **CONTENTIONS**

A. **Safety-Related Contentions**

(1) Programmatic

NEV-SAFETY-01 - DOE INTEGRITY

1. A statement of the contention itself

The LA cannot be granted because DOE lacks the requisite integrity to be an NRC licensee.

2. A brief summary of the basis for the contention

DOE's continuing and past actions related to Yucca Mountain reveal a pattern of material false statements and omissions and an elevation of schedule considerations over safety and compliance. Taken together, these actions indicate that DOE has a defective safety culture and lack of integrity that are inconsistent with being a responsible NRC licensee.

3. A demonstration that the contention is within the scope of the hearing

This issue must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. § 63.31(a)(1) and (2), that there is reasonable assurance of safety, and the issue is within the scope of the hearing as provided in section II, paragraph 1 of the notice of hearing. Moreover, long-standing NRC case law establishes that an applicant's integrity is a proper consideration in a licensing hearing. *See, e.g., Georgia Institute of Technology (Georgia Tech Research Reactor)*, CLI-95-12, 42 NRC 111 (1995); *Georgia Power Company (Vogtle Electric Generating Plant, Units 1 and 2)*, CLI-93-16, 38 NRC 25 (1993).

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This issue must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. § 63.31(a)(1) and (2), that there is reasonable assurance of safety, and the issue is therefore material. Moreover, long-standing NRC case law establishes that issues with respect to an applicant's integrity are material ones. *See, e.g., Georgia Institute of Technology (Georgia*

Tech Research Reactor), CLI-95-12, 42 NRC 111 (1995); *Georgia Power Company (Vogtle Electric Generating Plant, Units 1 and 2)*, CLI-93-16, 38 NRC 25 (1993).

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

NRC rightfully emphasizes the need for a "safety conscious work environment" in which safety is the top priority and communications with the NRC are truthful, complete, and timely. In NRC's parlance, a deficient work environment, or deficient safety culture, is a "cross-cutting" issue that permeates all aspects of safety performance and constitutes the root cause of multiple types of safety problems. NRC explicitly modified its nuclear inspection program to include consideration not only of whether "an environment exists in which employees feel free to raise concerns," but also of whether "management . . . displays behaviors that reflect safety as an overriding priority." *See* "NRC Operating Reactor Assessment Program" (11/27/2007), IMC (Inspection Manual Chapter) 0305 at 38-39. *See also* "NRC Supplemental Inspection for Repetitive Degraded Cornerstones, Multiple Degraded Cornerstones, Multiple Yellow Inputs, or One Red Input" (10/26/2006), IP (Inspection Procedure) 95003 at 57, *et seq*. On grounds less compelling than those described below, NRC ordered licensees to independently evaluate and to upgrade their culture and performance. *See, e.g.,* "Approval to Restart the Davis-Besse Nuclear Power Station, Closure of Confirmatory Action Letter, and Issuance of Confirmatory Order" (03/08/2004), LSN# NEV000005419; "Confirmatory Order (Effective Immediately) Office of Investigation Report No. 3-2005-010," Point Beach (01/03/2007), LSN# NEV000005435; and "Confirmatory Order (Effective Immediately)," D.C. Cook (04/04/2007), LSN# NEV000005453; and " Confirmatory Order for Program Improvements (Effective Immediately)" Nuclear Fuel Services (07/18/2007), LSN# NEV000005439.

Examples abound indicating that DOE abetted or tolerated, if not established, a culture in which meeting artificial schedules was more important than safety or compliance, and withheld material safety information from the NRC, with apparent willful intent. These examples are as recent as the tendering of the LA and cannot be dismissed as irrelevant prior history. They show that DOE had, has, and likely will continue to have a deficient safety culture.

In 2004, in order to meet a 2004 artificial deadline for submission of the LA, DOE certified the completeness of its LSN document collection under circumstances where it knew, or must have known, that the collection was not complete and that its certification violated NRC regulations. The PAPO Board found in LBP-04-20, 60 NRC 300 (2004) that DOE's approach to certification "strains credulity." *Id*. at 319. Rather than comply fully with NRC regulations, DOE "forged ahead on June 30, 2004, failing to produce tens of thousands of late gathered documents" because "DOE and its agents did not get their act together in time to meet DOE's own self-imposed deadline." *Supra* at 325. Indeed, DOE's non-compliance was entirely willful, for as the PAPO Board held, there was "a fundamental and system-wide problem caused by a conscious DOE decision to certify on June 30, 2004, before DOE's privilege review was finished." *Supra* at 320.

A disregard for safety infected DOE's preparation of the LA in the several years before it was filed. DOE OCRWM Director Sproat established an artificial deadline of June 30, 2008 for submission of the application. He testified before the NRC's Advisory Committee on Nuclear Waste (ACNW) that "[t]hat's no later than Monday, June 30, 2008. I know exactly when that date is and everybody working on this program right now knows exactly when that date is." ACNW meeting transcript for April 10, 2007, LSN# NEV000003601 at 10. This top-down directive created a culture within the YMP where schedule was apparently deemed supreme.

Accordingly, after DOE chose Sandia to be the Lead Lab to perform the TSPA, an internal Sandia e-mail message was sent that emphasized, in no uncertain terms, the overriding importance of the June 2008 application filing deadline. This statement, in an internal e-mail message dated October 15, 2006, LSN# DN2002359161 at 1, instructs Sandia personnel that the "TSPA needs to have form and function frozen by 12/15/06 in order to meet the June/2008 LA submittal," and that "delays are not acceptable." As the statement explains further:

> It is clear from the words of Ward Sproat that a License Application will be submitted in June of 08. It was clear from Andrew [S. Andrew Orrell, Sandia's Senior Program Manager for Yucca] that Ward Sproat has every confidence in Sandia that we will meet this schedule and that Sandia will not let DOE down. As Andrew said, it is time to put pencils down and wrap-up this work. We need to identify risks and then mitigate them in such a way that we have product that is docketable and adequately defensible for submittal in June of 08. Delays in schedule can no longer be tolerated if we are to succeed. While some risk can be carried forward into License Defense space we must endeavor to develop a defensible LA on time.

Thus, the document indicates that schedule clearly drives the product. If Sandia cannot complete all of the scientific analyses recommended in support of the application in time to meet the schedule, it will deal with this by "mitigating" those risks. But what if "mitigation" results in the safety evaluation being incomplete? Is meeting a schedule more important than eliminating gaps in the safety analysis? And what happens if someone believes more time or analysis is technically necessary to ensure a credible safety evaluation? The answers appear to be provided in another broadly distributed internal Sandia e-mail message dated October 10, 2006, only a few days later. LSN# DN2002319598 refers to an "all hands" meeting of Sandia personnel, held in order to present "Lead Lab kick-off information." At the meeting, Sandia's entire Yucca work force was apparently told specifically that they would be "all out of a job" if the June 30, 2008 DOE deadline for submission of the application was not met. *Id.* at 1. "Any slips in schedule will be recovered by cutting scope. There is no allowance for not meeting schedule." *Id.*

Indeed, the author of the e-mail explains that "my responsibility, as NFE Manager, is to ensure that the 3 priorities schedule, defensibility, and credibility in that order, are satisfied." *Supra* at 2 (emphasis added). In other words, it was more important to meet an arbitrary deadline for getting the application filed than it was for the application to be defensible, and more important to make the application defensible than for it to be technically credible. And this skewed ordering of priorities was enforced under the premise that if the arbitrary schedule was not met "we are all out of a job."

The unfortunate results of DOE's skewed priorities are manifested in other internal e-mail messages and Yucca Project documents. For example, a "technical work plan" prepared by Sandia for the "defensibility of technical products" states that "residual vulnerabilities [in the LA] for which resolution must be deferred for reasons of priority or time constraints will be reflected in the project Risk Register and addressed prior to the hearing on the LA [license application]." LSN# DN2002502865 (1/25/2007) at x. DOE's comments on the document, DN2002379717 at 1, suggest that DOE had no problem with the cited excerpt. Therefore, it was acceptable to DOE if the LA filed with the NRC included known but undisclosed "residual vulnerabilities" in safety evaluations but, if NRC Staff, Nevada or some other stakeholder were to find out about them, DOE (with Sandia's assistance) would need to be ready with some explanation.

Other, earlier e-mail messages are even worse. They show: (1) some YMP personnel adopting the position that NRC should be given "minimum information" (e-mail message from R. Rickertsen to P. Swift, dated August 1, 2002, DEN001231578 at 1); (2) some YMP personnel believing that "proof that will get us through the regulatory hoops" need not be "rigorous" (e-mail string from L. Rickertsen to L. Rickertsen, last dated September 3, 1996, LSN#

DEN001222278 at 1); (3) sustained efforts to "keep some people in blissful ignorance" about technical problems (e-mail message from L. Rickertsen to M. Scott, dated June 25, 1998, LSN# DN2000734458 at 1); (4) a program that carefully manipulates statistics to assure that the results are always "in the right place" (email string from L. Rickertsen to E. Taylor, last dated January 28, 1998, LSN# DEN001212230 at 1); (5) a program where a senior scientist expresses a concern about "how to fight lies and misinformation" and opines that "no one seems to care about the truth" (e-mail string from L. Rickertsen to J. Docka, last dated March 3, 1998, LSN# DEN001225591 at 1); and (6) a project where technical experts call senior officials "swindlers," "certifiable jerks" (and worse), the management of the principal contractor is called "craven and ignorant," and there is concern about what would happen if Nevada learned about certain internal communications (e-mail string from L. Rickertsen to E. Taylor, last dated September 28, 1998, LSN# DN2001131123 at 4).

Before tunnel construction began for the exploratory study facility at Yucca Mountain, DOE knew that tunneling would release toxic respirable silica, that harm from respirable silica was completely preventable, and that engineering and administrative controls along with respiratory protection were necessary to protect its workers from that dust. But, because of concerns about schedule and possible litigation, DOE failed to implement any controls or respiratory protection for almost three miles of tunneling, leaving its workers unprotected and overexposed. The details of this sorry episode are provided below. While this episode deals with non-radiological hazards, it offers another example where DOE elevated schedule and cost (litigation cost) over safety, and buttresses the contention that DOE has a deficient safety culture.

Long before construction began on the Exploratory Site Facility ("ESF") tunnels at Yucca Mountain in October 1994, DOE knew that toxic silica dust would be a hazard, and as of 1988, DOE knew that Yucca Mountain was laden with silica. *See* "Comments for the Exploratory Studies Facility, North Area Design Studies Review," 06/26/1991, LSN# DEN000129132 at 1; and "Letter regarding the opportunity to submit comments in the Title I design review for the Exploratory Shaft Facility (ESF) portion of the Nevada Nuclear Waste Storage Investigations Project," 04/20/1989, LSN# DEN000596707 at all pages. Further, DOE knew that dry-drilling silica-laden rock would release respirable silica, which was extremely hazardous to health. *See* "Evaluation of potential dust-related health hazards associated with drilling," 01/29/1988, LSN# DEN000556071, pages unnumbered but *see generally* §§ 1.0 and 4.0. DOE further knew that the harm from exposure to respirable silica in the tunnels was completely preventable. *See* NIOSH ALERT "Preventing Silicosis and Death in Rock Drillers" (08/1992), LSN# NEV000004697 at 8; and "Update NIOSH issues nationwide alert on silicosis" (11/18/1992), LSN# NEV000004578 at 1. DOE knew that prevention of that harm would require excellent dust control (*see* "Evaluation of Dust Hazards in an Underground Dry Drilling Operation. American Industrial Hygiene Conference: Joint activities in industrial hygiene" (04/11/1989), LSN# DEN000076430 at 1), especially through engineering and administrative controls (*see* LSN# DEN000076430 at 1), daily monitoring (*see* LSN# DEN000596707 at 2), and as a last resort, with personal protective equipment (*see* LSN# DEN000076430 at 1).

But, as the NWTRB reported to Congress, DOE failed to incorporate necessary engineering controls for dust management on the tunnel boring machine ("TBM"), for which it alone designed the specifications, despite knowing that silica dust likely would be a hazard to all in the tunnels. *See* "Underground Exploration and Testing at Yucca Mountain - A Report to Congress and the Secretary of Energy, Nuclear Waste Technical Review Board, October 1993," 10/01/1993, LSN# DN2001635791 at vii and 23. Instead, DOE focused on ways to make the

TBM run faster. *See* "Yucca Mountain Site Characterization Project, Tunnel Boring Machine Modifications Report, Exploratory Studies Facility," 10/19/1995, LSN# DEN001275498 at 25. Moreover, even though the federal government's tunneling experts, Mine Safety and Health Administration ("MSHA"), advised DOE to sample daily for dust, *see* LSN# DEN000596707 at 2, DOE took only 95 samples from roughly October 1994, when the TBM began (*see* "Tunnel activity report for Sta. 0+58.30 to Sta. 27+94.53 dated from October 30, 1994 to November 15, 1995, at 01 thru 75" (11/15/1995), LSN# DEN000020399 at 1), until mid-December 1995, when the tunnel was two miles long (*see* "Tunnel activity reports - from Sta. 27+95.90 to Sta. 56+25.23 dated from November 15, 1995 to June 10, 1996" (06/10/1996), LSN# DEN001255756 at 76 thru 153 (in particular, *see* entry for December 13, 1995 at 87)).

Worried about "collection of data from which technical disputes [could] arise," in November 1995 DOE delayed conducting a long-overdue baseline air quality assessment of the ESF. *See* "Exploratory Studies Facility (ESF) Air Quality Assessment" (11/03/1995), LSN# DEN001377103 at 1. Until mid-1996 DOE made available paper dust masks, utterly useless protection against respirable silica. *See* "Respirator Program" (03/28/1996), LSN# DEN001389652 at 1. After Christmas 1995, a concerned LANL industrial hygienist broke ranks to take dust samples and have them analyzed without permission. The results showed overexposures to respirable silica. *See* "Air Sampling Results of the Exploratory Studies Facilities (ESF) Tunnel Operations" (02/01/1996), LSN# DEN000746512 at 1, 2. Simultaneously, the TBM was advancing at an expectation-breaking rapid pace, 110 days ahead of the "Program Plan." *See* "Tunnel Boring Machine Modifications Report 1995, Year in Review, Exploratory Studies Facility" (01/25/1996), LSN# DN2001654959 at 1.

Thanks to the LANL whistle-blower, sampling began in earnest in February 1996. However, DOE did not prepare a silica respiratory program until late spring, long after it was needed and after the tunnel was three miles long. *See* LSN# DEN001389652 at 1. DOE did not implement fully the silica respiratory program until November 1996, when the tunnel was more than four miles long. *See* "Respirator Requirements" (11/21/1996), LSN# NEV000004571 at 1-3. Hole-out for the five-mile ESF was only five months later, 25 April 1997. *See* "Tunnel Activity Reports - from Sta. 56+26.46 to Sta. 78+76.68 dated from June 10, 1996 to June 04, 1997" (06/04/1997), LSN# DEN000342431 at 154 thru 214 (in particular, *see* Entry for April 25, 1997 at 214).

Respirable silica exposures continued during cross-drift ("ECRB") construction (March – October 1998) and DOE's patchwork engineering controls proved ineffective, despite the "lessons learned" from ESF construction regarding the need for engineering controls to manage dust. *See* "Dust and Ventilation Update from the IH Perspective" (08/12/1998), LSN# DN2000818181 at 1, 2. DOE quickly created a Silica Protection Program in April 1998, with the bottom line concern to "*reduce potential for litigation*," despite its expressed exalted interest in safety and health. "Silica Protection Program (SPP) Implementation" (03/24/1998), LSN# NEV000004611 at 9. DOE hurriedly approved protective clothing "to highlight our attention to worker health and *further reduce liability* associated with the innate silica contamination . . . ." "Protective Clothing" (04/23/1998), LSN# DEN000600033 at 1. In April 2001, a certified industrial hygienist responding to DOE's concerns about silica issues, advised DOE that silica was a known problem at the ESF and, if left untended, would result in disastrous effects, including, and especially, lawsuits, "*even class actions*," for DOE's lack of concern. "Silica, Sampling, and Surveillance - An Issue Paper" (04/04/2001), LSN# DEN001008959 at 1, 2.

Nonetheless, as late as March 2000, DOE still had no apparent risk criteria established for the abnormally high silica concentrations present. *See* "Dust and Silica Control" (03/13/2000), LSN# DN2000153826 at 1, 2; and "Civilian Radioactive Waste Management System Management and Operating Contractor (M&O) Environmental, Safety and Health (ES&H) Monthly Report for May 2000" (06/22/2000), LSN# DN2001871427 at 2. DOE focused more on the cost to protect workers from silica, underfunding the project, which has prevented necessary repairs and engineering controls to safeguard the workers from toxic dust. *See* "Re: Silica Control" (06/21/2000), LSN# DN2001845014 at 1, 2; and "Email - System Structure & Component Status of ESF/ECRB Which Could Impact Near Term Testing Activities" (05/07/2002), LSN# DEN000496624 at 1. Further, eight years after tunneling began, in 2002 a Bechtel/SAIC ("BSC") Assessment Report showed that (a) the current work order indicated no specifications for dust/silica control processes or equipment, (b) there were no records to establish appropriate sampling, (3) housekeeping was deficient for dust removal underground, and (4) there was no silica training tailored to the Yucca Mountain project. "Assessment Report 02-06, Silica" (06/10/2002), LSN# DEN001376705 at 3, 4, 14, 17, and 21-22.

In response to a worker's written concern about his exposure to toxic minerals during the ESF/ECRB construction period, DOE whitewashed its slow, obviously unplanned, and ineffective response to the dust situation, of which it was aware long before tunneling began. *See, e.g.*, "3 12 2003 Griego Complaints Re Toxic Exposure" (03/12/2003), LSN# NEV000004714, all; OCRWM Report on Their Investigation of Griego Allegations (10/15/2003), LSN# NEV000004718, all; and "Employee Concern 01-128(C)" (02/07/2002), LSN# NEV000003941, all. Thanks only to that persistent worker, in 2004 DOE finally instituted a Silicosis Screening Program for the 1200-1500 workers who, as DOE put it, "*may* have been exposed to airborne silica" in the tunnels. "Announcement of Silicosis Screening Program" (02/18/2004) LSN# DEN001223377 at 1, 2.

These examples of a lack of integrity and a deficient safety culture are not confined to the past. They continue to the present. For example, the license application omits any mention whatsoever of the independent review of DOE's infiltration model performed at DOE's request by ORISE (Oak Ridge Institute for Science and Education). ORISE provided the results of this independent review to DOE's Yucca Mountain Project on April 30, 2008, after considering comments on a January 2008 draft of the report submitted by DOE on February 14, 2008 (*see generally* LSN# DEN001594989 and LSN# DEN001595302). The conclusions of this independent review are stark and unquestionably material. ORISE concludes (Summary at 1) that "the model report does not provide a technically credible spatial representation of net infiltration at Yucca Mountain." The report cites here (Summary, page 1) to the following issues:

(1) a "critical lack of site-specific hydrological, surface, and subsurface information,"

(2) a failure to incorporate "at least one potentially important hydrologic process," which "may be one reason the model results appear to underestimate net infiltration beneath wash environments and therefore imprecisely represent the spatial variability in net infiltration," and

(3) "assumptions [that] oversimplify a complex landscape and associated hydrologic processes" and that "have not been adequately corroborated by field and laboratory observations at Yucca Mountain."

One searches in vain for any mention of this report in section 2.3.1.3.2.1.3 of the LA SAR entitled "Soil Properties," which would be the most pertinent section, in any other part of the LA, or in any LA reference. This is a willful omission of important safety information.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

DOE's application does not address integrity, and no particular sections of the application are directly pertinent to this issue. This is because there is no requirement in any of the Commission's regulations for any applicant to affirmatively demonstrate its integrity. However, concerns about integrity present material issues, as explained above, and an allegation that DOE lacks sufficient integrity presents a genuine dispute with DOE. Supporting reasons are given in "Supporting facts and opinions" above, and may be summarized as follows. DOE and its contractors' continuing and past actions related to Yucca Mountain reveal a pattern of material false statements and omissions and elevation of schedule considerations over safety and compliance. These actions indicate that safety is not an overriding priority within DOE's Yucca Mountain project, and that DOE has a defective safety culture and lack of integrity that are utterly inconsistent with being a responsible NRC licensee.

NEV-SAFETY-02 - DOE MANAGEMENT

1. A statement of the contention itself

The LA cannot be granted because DOE lacks the requisite management ability to construct and operate a safe repository.

2. A brief summary of the basis for the contention

DOE's current and past activities related to Yucca Mountain, as well as its activities with respect to its uniform mismanagement of other large projects, establishes a level of management incapacity on the part of DOE that would jeopardize the design, construction, and operation of a proposed Yucca Mountain repository, would fail to protect the public health and safety and that would fail to comply with NRC requirements, thus rendering DOE unqualified to be an NRC licensee.

3. A demonstration that the contention is within the scope of the hearing

The issue of DOE's management competence must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. §§ 63.31(a)(1) and (2), that there is reasonable assurance that the health and safety of workers and the public will be protected and NRC requirements will be met, and the issue is within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing. Settled NRC case law stands for the proposition that an applicant's management competence is a proper consideration in a licensing proceeding to determine entitlement to an NRC license. *Piping Specialists, Inc.*, 36 NRC 156, 1992 NRC Lexis 63 (1992); *Louisiana Energy Services, LP*, 34 NRC 332, 1991 NRC Lexis 68 (1991); *Sequoyah Fuels Corp.*, 24 NRC 489, 1986 NRC Lexis 42 (1986).

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

The issue of DOE's management competence must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. §§ 63.31(a)(1) and (2), that there is reasonable assurance that the health and safety of workers and the public will be protected and NRC requirements will be met, and the issue is therefore material to the findings NRC must make. Settled NRC decisions establish the importance of the management competence of a prospective NRC licensee as a condition precedent to its acquiring a license, and also recognize that the **pattern** of its management performance in prior large projects is a cognizant factor to be considered in determining the likelihood of management competence on the project for which an NRC license is sought. *Sequoyah Fuels Corp.*, 24 NRC 489, 1986 NRC Lexis 42 (1986) (the propriety of dealing with the management competence issue was presumed, and the only issue was whether a formal adjudicatory process need be interposed where none was required; finding that convening a formal hearing would add appreciably to the administrative burden, the Commission held "the question of management competence as a barometer for measuring the likelihood of safe facility operation, while not a classic scientific or engineering issue, nonetheless is a matter that generally involves the agency's technical judgment about the adequacy of the structure and qualifications of applicant's management as it impacts upon the applicant's ability to conduct its proposed activities in compliance with regulatory requirements for the protection of the public health and safety").

In addition, NRC has acknowledged that the prior pattern of management competence of a license applicant is relevant to its license entitlement in a new, unrelated licensing proceeding. In *Carolina Power & Light Co.*, 24 NRC 802, 1986 NRC Lexis 1 (1986), the parties to the proceeding concurred and stipulated to a contention asserting: "The applicants have not demonstrated the adequacy of their managing, engineering, operating, and maintenance personnel to safely operate, maintain, and manage the Shearon Harris Nuclear Power Plant **as evidenced by their record of safety and performance at their other nuclear power facilities**. A pattern of management inadequacies and unqualified and/or inadequate staff is likely to be reproduced at Shearon Harris Nuclear Power Plant and result in health and safety problems." *Babcock & Wilcox Co.*, 41 NRC 1, 1995 NRC Lexis 1 (1995) (addressing past pattern of management competence from the positive side, concluded "the evidence presented by B&W and the NRC staff demonstrates that B&W has had an excellent record of performance at both its Apollo and Parks Township facilities for at least the past 15 years and there is every reason to expect that such performance will continue").

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Over the 20-plus years since Congress instructed DOE to evaluate only the Yucca Mountain site in Nevada for the potential construction and operation of a nuclear waste repository, DOE has been involved in a number of high-dollar, high-profile projects, establishing an abysmal track record along the way, with schedule, cost, and contractor oversight particularly out of control. A high-ranking DOE official discussed the future of the Department a decade ago: "Regardless of the future of DOE, many long-term issues, such as contractor reform, major acquisitions, and environmental cleanup and waste management, will need addressing. It is time for a fundamental rethinking of DOE's missions" (GAO/T-RCED-96-224, LSN# NEV000005434 at 1). Testifying before the United States Senate in 1996, the same DOE official admitted that "its approach to contract management, first created during the World War II Manhattan Project, allowed private contractors to manage and operate billion-dollar facilities with minimal direct federal oversight yet reimbursed them for all of their costs regardless of their actual achievements. . . . Weak management and information systems for evaluating a program's performance has long hindered DOE from exercising effective oversight." *Id*. at 2.

Notwithstanding these admissions, DOE's management and contractor oversight remained deficient. Thus, some eight years later, on the eve of a long-promised License Application submittal by DOE to the NRC for the Yucca Mountain project in December 2004, DOE found its general contractor entitled to a multimillion dollar bonus for completing the License Application in a timely manner. "DOE Revises Yucca Schedule" (11/23/2004), *Las Vegas Review Journal*. Then, only a week before the application was promised to be filed with NRC (LSN# NRC000027221), DOE "pulled the plug" on that plan, and the License Application was not filed (still incomplete) until almost four years later in June 2008.

DOE has admitted to Congress that its own survey of "nearly 44 former DOE executives and experts on energy policy" resulted in a majority proposing to move DOE missions to other agencies or entities, including moving "the management and disposal of civilian nuclear waste to a new public-private organization, a new government agency, or the Environmental Protection Agency." (NEV000005434 at 2.) Addressing contract oversight reform, DOE admitted "DOE has a long history of management problems. At the core of many of these problems is its weak oversight of more than 110,000 contractor employees, who perform nearly all of the Department's work. Historically, these contractors worked largely without any financial risk, they got paid even if they performed poorly, and DOE oversaw them under a policy of 'least interference.'" Although more and greater delays were to come in the future, even in 1996, DOE predicted its delay of the Yucca Mountain project: "Although an operational repository was originally anticipated as early as 1998, DOE does not expect to determine until 2001 if the site at

Yucca Mountain, Nevada, is suitable and, if it is, to begin operating a repository there until at least 2010." *Id*. at 3.

DOE's euphemism that an operational repository was "anticipated" by 1998 sidesteps the more damning fact that DOE was **required by law** to open a repository by 1998, and its failure to do so resulted in successful lawsuits by nuclear utilities which have already cost DOE billions of dollars (*Indiana Michigan Power Co. v. Department of Energy*, 88 F.3d 1272 (D.C. Cir. 1996)), and promise to continue to cost DOE billions of dollars more until a repository is available, a hypothetical which DOE now postpones until at least 2020. What is particularly stunning is not merely the repeated postponement by DOE of its schedules for completing YMP, but the duration of those postponements and their regularity. Thus, in 1997, DOE told the GAO ("Nuclear Waste: Impediments to Completing the Yucca Mountain Repository," GAO/RCED-97-30 (01/17/1997), LSN# NEV000003693 at 4) that it anticipated submitting a License Application to NRC in March 2002 – in other words, a five-year forecast. Instead, DOE submitted its LA in June 2008, 11 years (double the amount of time) later.

In 1999, a high-level White House panel condemned DOE as a "dysfunctional bureaucracy that has proven it is incapable of reforming itself" while pointing out that DOE had more than 50 major facilities in 35 states, that it typically contracts for the management and operation of its major facilities, and that it has more than 100,000 contractor employees at those facilities ("Government at the Brink, Vol. II, An Agency by Agency Examination of Federal Government Management Problems Facing the Bush Administration," Committee on Governmental Affairs, U.S. Senate (06/2001), LSN# NEV000005493 at 30-32). GAO reiterated in 2001, "For years, we and others have reported on problems with [the Department of Energy's] contract management, which we have defined broadly to include contract administration and project management. These problems have included non-competitive awards, cost and schedule overruns, inadequate oversight of contractors' activities, over-reliance on cost-reimbursement contracts, and an inability to hold contractors accountable" ("Major Management Challenges and Risks, Department of Energy," GAO-01-263 (01/01/2001), LSN# DN2001769384 at 40).

The Senate Committee adopted a GAO conclusion that "DOE's lack of technical expertise to oversee the design, construction, and operation of its major system acquisitions . . . has been chronicled since DOE's early years" ("Department of Energy: Improving Management of Major System Acquisitions," GAO/T-RCED-97-92 (03/06/1997), LSN# NEV000005468 at 5); and "[the Department] has difficulty managing other large projects. Our past reviews have shown a consistent pattern of poor management and oversight by [the Department of Energy]" ("Nuclear Waste: Department of Energy's Hanford Tank Waste Project – Schedule, Cost and Management Issues," GAO/RCED-99-13 (10/01/1998), LSN# NEV000005485 at 18).

In January 1999, GAO, observing that DOE relied on contractors to perform about 90 percent of its work, found that, from 1980 through 1996, DOE had terminated 31 out of 80 major projects after expenditures of $10 billion and had completed only 15, most of which were behind schedule and over-budget. With respect to 34 ongoing projects, GAO found that 27 had cost overruns averaging over 70 percent, and many were behind schedule ("Major Management Challenges and Program Risks, Department of Energy," GAO/OGC-99-6 (01/01/1999), LSN# NEV000005420 at 6.

The Senate Committee focused its examination of DOE on its health and safety record, finding that "ensuring the safety and health of its workforce and the public is one of the Department's most difficult long-term challenges. Safety and health issues encompass all activities relating to the identification, testing, handling, labeling, cleanup, storage, and disposal of radioactive and hazardous waste. The Department has had a troubled history when it comes to this issue" (NEV000005493 at 37). The so-called Safety Conscious Work Environment aspect of DOE's culture has been addressed in a different contention (*see* NEV-SAFETY-01).

GAO did a "Fundamental Reassessment" of DOE's performance in 2001 (NEV000003676) in which it noted that "The Department has persistent management weaknesses that have led directly to a wide range of performance problems, including major cost overruns and schedule delays in a variety of noteworthy projects." *See* GAO-02-51, "Department of Energy: Fundamental Reassessment Needed to Address Major Mission, Structure and Accountability Problems" (12/2001), NEV000003676 at 2. The GAO criticized DOE's weak culture of accountability, concluding that DOE has not been able to develop a technically competent work force to oversee its contractors nor hold its own staff accountable. GAO found this particularly significant "given that DOE spends most of its budget through these contractors" making its oversight "crucial for its mission's success and overall effectiveness." *Id*. at 6. GAO (*id*. at 19) quotes the National Research Council as calling DOE one of the most inefficient organizations in the federal government and finding that:

> DOE projects commonly overrun their budgets and schedules, leading to pressures for cutbacks that have resulted in facilities that do not function as intended, projects that are abandoned before they are completed, or facilities that have been so long delayed that, upon completion, they no longer serve any purpose. In short, DOE's record calls into question the credibility of its procedures for developing designs and cost estimates and managing projects.

As recently as September 2008, GAO again looked at DOE's track record for large projects, concluding that **nine out of ten** major projects it reviewed had life-cycle baseline cost increases from a low of $139 million for one project to a high of nearly $9 billion for another, and life-cycle baseline schedule delays from 2 to 15 years. For one project, the baseline was significantly modified only seven months after it had been updated and "validated" by an independent review, while other projects experienced life-cycle cost increases of as much as $9 billion and delays of up to ten years, only one or two years after such independent reviews and validations of cost and budget ("Action Needed to Improve Accountability and Management of DOE Major Cleanup Projects," GAO-08-1081 (09/26/2008), LSN# NEV000005496 at 5, *et seq*.). The GAO laid the blame at the foot of DOE's failure to effectively use management tools to oversee the scope of work, costs and schedule. Ironically, the release of this GAO report coincided with a new DOE cost estimate for completion of YMP: only seven years after DOE had predicted a total cost of $72 billion, it ballooned its estimate to $96 billion ("Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program, FY2007" (07/23/2008), LSN# NEV000005495 at 1-3). The occasions during its YMP work have been legion where DOE has exhibited its chronic incompetence in large project management, particularly poor oversight of its contractors, and a poor record on health and safety, which provide the opposite of any reasonable assurance that management of the design, construction, and operation of YMP would be addressed competently by DOE, if it were awarded a license. Following are just a few examples:

a. DOE Oversight of Its Contractors: DOE's failed oversight on YMP has included two of its national laboratory contractors, the "lead lab," Sandia National Laboratory (SNL) and Lawrence Livermore National Laboratory (LLNL). Among many instances of lesser significance, SNL erred by hundreds of feet in locating geologic faults ("Preliminary 2007 Geotechnical Drilling Results – for the Waste Handling Buildings and Aging Pad Areas, Yucca Mountain, Nevada" (5/21/2007), LSN# DN2002502636) nearby aging pad locations which it proposed to utilize for storage of spent fuel (again, the analysis by DOE's contractors of the "most studied piece of real estate in the world" still contained monumental deficiencies 20 years after site characterization began). In the case of LLNL, QA audits of its laboratory experiments disclosed (in one corrosion experiment) the use of an improperly calibrated Visaila temperature humidity probe ("Observation Audit of Bechtel SAIC Company, LLC, Audit of Scientific Investigation, Waste Package, and Drip Shield Degradation" (1/9/2006), LSN# DN20002478075), which rendered indeterminate the entire results of the LLNL experiments; likewise, LLNL's "general corrosion" experiments ("Technical Work Plan for: Weight-Loss Measurements on Alloy 22 Coupons" (9/2008), LSN# DEN001601911 at 1) were rendered indeterminate due to inept laboratory techniques which allowed uncleaned plates to be utilized in measuring the amount of Alloy-22 "shed" by experimental samples. DOE's accordingly deficient oversight of its contractors remains unabated decades after and numerous GAO reports after it came to prominence as a DOE chronic problem area.

b. Exploratory Studies Facility Engineering Controls: Bearing ultimate responsibility for all facets of the Yucca Mountain Project, including and especially worker safety and health, DOE failed its duty to incorporate and implement engineering controls in order to protect the workers from the known silica-dust hazards that would result from dry-drilling the Exploratory Site Facility ("ESF") tunnels in Yucca Mountain. DOE knew the mountain's mineralogy, containing approximately 70-75 percent silica by weight. "Comments for the Exploratory Studies Facility, North Area Design Studies Review" (06/26/1991), LSN# DEN000129132 at 1; Letter regarding the opportunity to submit comments in the Title I design review for the Exploratory Shaft Facility (ESF) portion of the Nevada Nuclear Waste Storage Investigations Project (04/20/1989), LSN# DEN000596707 at 1-2; "Occurrence of Silica Phases in Welded Ash" (06/11/1992), LSN# NEV000004459 at 1, 13-17. DOE knew that the harm from exposure to respirable silica was completely preventable. "Preventing Silicosis and Death in Rock Drillers" (08/1992), LSN# NEV000004697 at 2-11; "Update NIOSH issues nationwide alert on silicosis" (11/18/1992), LSN# NEV000004578 at 1-3. DOE knew that prevention of that harm would require excellent dust control, especially through engineering and administrative controls, "Evaluation of Dust Hazards in an Underground Dry Drilling Operation," American Industrial Hygiene Conference: Joint activities in industrial hygiene (04/11/1989), LSN# DEN000076430 at 1, daily monitoring, DEN000596707 at 2, and as a last resort, with personal protective equipment. DEN000076430 at 1. Nonetheless, despite being fully informed, DOE failed to prepare properly key components to control toxic dust in the ESF. One key component was the TBM itself. Although fully informed of the need, DOE failed to incorporate appropriate dust collection and containment engineering controls on the tunnel boring machine ("TBM"). DOE hired costly experts, after the ESF was roughly three miles long, who recommended post-design modifications to the TBM to control dust, such as dry scrubbers, wet scrubbers, a baghouse, additional local exhaust, dust curtains, and spot dust collectors. "Abatement Plan: Respirable Silica Dust" (10/01/1997), LSN# DN2001500115 at 3-5. By August 1996 these post-design controls still were not in place. "Transmittal and follow-up analysis to July 15 report of the Compliance Assistance Visit (CAV) conducted at Yucca Mountain by Mine Safety and Health Administration (MSHA) personnel on April 24-26, 1996" (10/08/1996), LSN# DEN000569938 at 1-2. Little wonder, as DOE considered the equipment for engineering controls overall too expensive and hard to justify with the tunnel over 80% complete. "Air Quality Report; informal memorandum" (08/08/1996), LSN# NEV000004432 at 3-25. Yet, incredibly, DOE contended in March 2004 that the TBM original design was "adequate for controlling dust." "Potential questions: Silica Document - Sid Dodd" (03/08/2004), LSN# DN2001082971 at 3 of 6 unnumbered pages. In October 1993, the NWTRB chastised DOE for its failures regarding the TBM design and purchase and overall project management. "Underground Exploration and Testing at Yucca Mountain - A Report to Congress and the Secretary of Energy," NWTRB (10/01/1993), LSN# DN2001635791 at v-vii, 1-28. The Board found that:

- DOE violated industry practice in developing its own specifications for the TBM. DN2001635791 at vii, 23.
- DOE placed greater emphasis on developing "a more efficient system for managing the exploratory facility design and construction." DN2001635791 at vii, 25-26.

Finally, the Board concluded that DOE was underfunding the project, ignoring cost incentive practices, and making decisions through "many different contractor organizations, multiple levels of management, and unclear accountability." DN2001635791 at 25-26. Further indicating DOE's ineptitude, DOE's own ES&H Management Plan Information System indicated in 1994 that the project lacked an overall Industrial Health program to manage a hazardous environment and that the potential harm from toxic dusts could be "catastrophic" in terms of human life, manpower, and overall project costs. "U.S. Department of Energy ES&H Management Plan, Information System Activity Data Sheet, Yucca Mountain Project Office, Open ES&H ADS REECo YMP Industrial Hygiene" (07/15/1994), LSN# DN2000000884 at §§ 28, 35. DOE insisted that the identified (post-design) engineering controls "would hurt the schedule and increase costs." "Air Quality Problem Status" (06/04/1996), LSN# NEV000004572 at 17-18. In September 1997, DOE conceded its failures: "The lack of consideration of possible health hazards in the planning, design, and installation of key ESF components resulted in significant cost and schedule impact, as well as unnecessary exposure to personnel when the health hazards became apparent."

c. Poor Health and Safety Oversight: DOE had and has the duty to ensure that all participants at Yucca Mountain comply with federal regulations for safety and health and industrial hygiene, but failed that duty by not controlling its contractors. The Secretary of Energy obligated DOE to ensure that all participants at Yucca Mountain comply fully with DOE Orders. "Environmental Protection Safety and Health Protection Standards; DOE Order 5480.4" (01/07/1993), LSN# NEV000004414 at 1-9 (and 10); "Federal Employee Occupational Safety and Health Program; DOE 3790.1B" (01/07/1993), LSN# NEV000004766 at 1-5 (and 6); "Worker Protection Management for DOE Federal and Contractor Employees; DOE 440.1" (09/30/1995), LSN# NEV000004461 at 1-6; "Order Worker Protection Management for DOE Federal and Contractor Employees; DOE 440.1A" (03/27/1998), LSN# NEV000004649 at 1-8; DOE Order 440.1B. DOE had and has the duty and authority to (a) ensure, among many other things, that its agents and contractors effectively implement worker protection programs and comply with those program requirements; (b) provide contractors with technical direction and criteria for contractor goals; (c) hold line personnel accountable for providing that direction; and (d) ensure immediate and effective remedial actions for imminent danger in order to remove workers from the hazard. NEV000004414 at 1-9 (and 10); NEV000004766 at 1-5 (and 6); Att. 1 at 1-2; Att. VII at 1-11; NEV000004461 at 1-6; Att. 1 at 1, 4; Att. 2 at 1; NEV000004649 at 1 - 8; Att. 1 at 2, 5; Att. 2 at 1 - 3, 8; [DOE Order 440.1B] LSN# NEV000004764 at 2-8. Regarding worker protection programs under the Orders, DOE was and is obligated to ensure that its contractors (a) identify existing and potential workplace hazards, such as silica-laden toxic dust; (b) assess worker exposure to those hazards; (c) implement hazard prevention/abatement processes to manage those hazards; and (d) control those hazards through engineering controls supplemented with administrative controls, and personal protective equipment if necessary thereafter. NEV000004766 at 1-5 (and 6); Att. VII at 4-9; NEV000004461 at 1-6; Att. 2, all pages (unnumbered); NEV000004649 at 1 - 8; Att. 2 at 1-16; [440.1B] NEV000004764 at 3-5; Att. 1 at 1-9 (and 10). DOE had little control over its tunnel construction manager, REECo, and the actual tunneling organization, Kiewit – the world's self-proclaimed largest and proudest tunneling company, boasting record-breaking production rates – and Kiewit's engineering subcontractor, Parsons Brinkerhof ("K/PB"). In May 1994, REECo advised DOE that K/PB was fully aware of the required respiratory protection requirements and planned to follow them. In August 1994, roughly 6 weeks before tunneling began, DOE told REECo/K/PB to put folks in respiratory protection because of the possibility of exceeding silica PELs. "Exploratory Study Facility Industrial Hygiene Program for Tunnel Boring Machine (TBM) Operations" (08/11/1994), LSN# DEN001043195 at 1. K/PB all but refused, unilaterally declaring that it would not tunnel at all if it had to comply with full-face power-air-purifying respirators. "Reynolds Electrical & Engineering Company, Inc,/Kiewit/Parsons Vertical Slice Management Assessment" (08/12/1994), LSN# DEN000322714 at A-17. K/PB directed paper dust masks to "give DOE some level of comfort." LSN# NEV000004713 at 2. DOE's lame response, apparently placing schedules above human health, was to remind K/PB to monitor and use respirators, if needed. DEN001043195 at 1. In fact, DOE did not make K/PB implement respiratory protection fully until November 1996, when the planned five-mile tunnel was more than four miles long, "Respirator Requirements" (11/21/1996), LSN# DEN001390562 at 1, with enclosure, DEN001376363 at 1-2, and then only after DOE issued a stop work order due to soaring respirable silica conditions and respiratory noncompliance in the ESF. LSN# DN2001653109 at 1. DOE's approved ventilation design called for two 66-inch ducts, but DOE caved to K/PB's demand to install only one. "Air Quality Report; Informal Memorandum"

(08/08/1996), LSN# NEV000004432 at 3-25; "Yucca Mountain Site Characterization Project, Tunnel Boring Machine Modifications Report, Exploratory Studies Facility" (10/19/1995), LSN# DEN001275498 at 8. Further, DOE failed to control the quality of K/PB's work. K/PB used inferior, unapproved materials to construct and install that one duct. "Exploratory Studies Facility (ESF) Lessons Learned, Revision 0 with Planning Sheets" (09/01/1997), LSN# DN2001656257 at A-25. Not only did the vent-line collapse (a completely avoidable situation), DN2001656257 at A-25, it leaked miserably. "Air Sampling Results of the Exploratory Studies Facilities (ESF) Tunnel Operations" (02/01/1996), LSN# DEN000746512 at 2; "ESF Tunnel Air Quality" (03/21/1996), LSN# DEN000728126 at 1. DOE eventually admitted that it had no control over K/PB's vent-line construction in the ESF. DN2001656257 at A-25. Yet, despite that supposed "lesson learned," DOE failed to control K/PB's construction and installation of the ECRB vent-line, which also collapsed and leaked. "Yucca Mountain Project TFDS Title Daily Activities for December 2000, Report # 3887, 3888, 3889, 3890, 3891, 3892, 3893, 3894, 3895, 3896, 3897, 3898, 3899, 3900, and 3901" (12/06/2000), LSN# DEN001404059 at 1 - 5, Reports 3887-3891; "Dust and Ventilation Update from the IH Perspective" (08/12/1998), LSN# DN2000818181 at 1-2. DOE also did not have full control over its own on-site Manager and Operator ("M&O"), TRW. By end March 1996, when the tunnel was almost three miles long, DOE ordered TRW to implement a respiratory protection program immediately, one that, pursuant to 29 CFR 1926.103, DOE should have made TRW implement prior to tunneling. "Respirator Program" (03/28/1996), LSN# DEN001389652 at 1. TRW balked, insisting that sample data would validate TRW's current strategy to use dust masks, which TRW claimed were adequate to protect the workers, "Your Letter, Respirator Program, Dated March 28, 1996" (04/08/1996), LSN# DEN001367471 at 1-2, in the face of contrary advice from DOE's hired expert who stated that they were not adequate. "Exploratory Studies Facility Air Quality Report December 1995 through September 1996" (11/20/1996), LSN# NEV000004496 at 1-2. Unable to control its contractors, DOE resorted to taking over construction management and conceded publicly in May 1999 that it still had little effective control of the overall project. "Oversight: Focused Review of the Yucca Mountain Project" (05/01/1999), LSN# NEV000003547 at 1-27.

d. **Titanium-7**: DOE's proposal to install some 11,000 drip shields is so far from reality that, despite having filed its License Application, it recently admitted to the NRC that it could not even provide to the NRC a simple sample of the Titanium-7, tons of which DOE proposes to use in fabricating drip shields. Instead, DOE suggested that it might be **years** before it could produce even a sample of the Titanium-7 to NRC of the type to be used in fabricating drip shields ("Response to the U.S. Nuclear Regulatory Commission (NRC) Request for Samples of Welded Titanium Plate" (1/4/2008), LSN# DEN001583135 at 1).

e. **Empirical Data**: Despite spending decades of time and billions of dollars assessing "the most studied piece of real estate in the world," DOE failed to acquire hard data to support many of its analyses (*e.g.*, soil and vegetation, volcanism, seismic, net infiltration, dust deliquescence, localized corrosion, microbially induced corrosion, and others) relying instead on modeling or expert elicitation where hard data could have and should have been acquired. Now, it intends to gather this information after the LA. For instance, DOE recently adopted a decades-long waste container corrosion test plan ("Long-Term Corrosion Testing Plan" (8/4/2008), LSN# DEN001600862, all pages) which anticipates DOE conducting long overdue experiments on corrosion of its planned waste container long after submittal of its License Application, on the basis that it did not conduct those tests earlier, and it did not even have the facilities to do so, which it plans instead to build in the future.

f. **Rock Fall**: NRC's contractor, the CNWRA, prepared an analysis in 2007 ("Summary of Current Understanding of Drift Degradation and Its Effects on Performance at a Potential Yucca Mountain Repository" (1/2007), LSN# NRC000029022 at xiii, xiv) in which it found that anticipated rock fall in the waste emplacement drifts would adversely impact waste containers both mechanically (physically) and thermally (by surrounding waste containers with debris and changing the thermal cooling mechanisms assumed by DOE). The CNWRA urged DOE to conduct analyses to resolve these issues, which DOE failed to do, allowing them to remain open issues.

g. **PVHA-U**: After preparing a PVHA in 1996, DOE acquired additional information of greater quality and critical importance through aeromagnetic testing in 2004. DOE attempted to explain the insignificance of the new information, but the NRC would not accept that the technical basis of DOE's volcanism analysis was any longer valid in view of the new information, and DOE formally committed to performing an updated expert elicitation on volcanism (PVHA-U). In the interim between the inception of DOE's PVHA-U (2004) and its LA filing (06/2008), the CNWRA performed an analysis of the new volcanism data acquired by DOE finding it critically important, and pointing out in particular the discovery of a sill formation under Yucca and additional volcanic anomalies resulting in a much greater likelihood of volcanic activity impacting Yucca than DOE's 1996 PVHA had found. Although DOE's contractor announced in May 2007 that final reports from all of the PVHA-U panelists would be in hand by July 2007, this did not occur, and at the time of LA, four years after beginning its marathon PVHA-U, DOE mysteriously still had not completed it and instead utilized its 12-year-old analysis of obsolete information as part of its TSPA analysis in the LA. Whether DOE's failure to complete and incorporate in its LA an analysis of critical information discovered in

2004 was mere ineptitude or a conscious effort to exclude new unfavorable information from the LA; either way, it is another example of DOE management incompetence which renders it unqualified for receipt of an NRC license for the nation's first nuclear waste repository.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

DOE's application does not address management capability, and no particular sections of the application are directly pertinent to this issue. This is because there is no requirement in any of the Commission's regulations for any applicant to affirmatively demonstrate its management capability. However, concerns about management capability present material issues, as explained above, and an allegation that DOE lacks sufficient management capability presents a genuine dispute with DOE. Supporting reasons are given in "Supporting facts and opinions" above, and may be summarized as follows. DOE has demonstrated on the YMP, on other pending large projects, and on prior large projects, most of them cancelled, that it lacks the management capability to construct and operate a nuclear waste repository at Yucca Mountain, and it is unqualified to be an NRC licensee.

NEV-SAFETY-03 - QUALITY ASSURANCE IMPLEMENTATION

1. A statement of the contention itself

SAR Subsections 5.0, 5.1, 5.1.2, and similar subsections and DOE's QARD (incorporated by reference in the License Application in Chapter 5), which promise DOE compliance with quality assurance (QA) requirements in the future, ignore the facts that DOE has been and continues to be unable to implement an adequate QA program and that there exists no basis for a reasonable assurance that DOE will do so in the future.

2. A brief summary of the basis for the contention

SAR 5.1 adopts DOE's QARD as embodying the requirements of the QA program applicable to quality related activities at the Yucca Mountain repository, addressing the requirements of 10 C.F.R. § 63.21(c)(20), 10 C.F.R. Part 63 Subpart G, and guidance in Section 2.5.1.3 of NUREG-1804; however, the QARD's mere regurgitation of the regulations' requirements cannot substitute for actual implementation which has been, continues to be, and in the future likely will be woefully deficient in the YMP.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain in Subpart G of 10 C.F.R. Part 63, Subpart G, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.21(c)(20) requires that DOE describe the QA program to be applied to the structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation. Before the Commission may authorize construction of a geologic repository operations area at the Yucca Mountain site, as stated at 10 C.F.R. §

63.31(a)(3)(iii) it must first determine that DOE's QA program complies with the required elements of Subpart G of 10 C.F.R. Part 63. Subpart G is comprised of 10 C.F.R. §§ 63.141 through 63.144. 10 C.F.R. § 63.142 contains a detailed explanation of the required component parts of an adequate QA program, and § 63.143 contains the simple mandate: "DOE shall implement a quality assurance program based on the criteria required by § 63.142." This contention challenges whether there is reasonable assurance DOE will in the future comply with §§ 63.142 and 63.143, and therefore raises a material issue.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE's QARD document, which is incorporated by reference in its SAR at Section 5.1, recites the requirements of NRC's regulation 10 C.F.R. Part 63, as well as the detailed criteria of 10 C.F.R. Part 63 Subpart G. However, as observed in NRC's Yucca Mountain Review Plan (YMRP), NUREG-1804 Rev. 2, at Section 2.5.1.3, "It is not sufficient for the U.S. Department of Energy documents to assert that particular requirements are met or provided for." Indeed, the YMRP specifically provides that the acceptability of DOE's QA program is evaluated by, in part, an NRC Staff assessment of the **ongoing** QA program activities. NUREG-1804 Rev. 2 § 2.5.1.2.

Beginning in the mid-1980s, and continuing beyond the time when DOE filed its License Application, to this very day, DOE has demonstrated that it is incapable of fully implementing an adequate QA program as mandated by 10 C.F.R. §§ 63.21(c)(20), 63.31(a)(3)(iii), 63.142, and 63.143.

DOE is required at 10 C.F.R. § 63.142(b) to establish and execute a compliant QA program; this compliant QA program must be applied to all structures, systems, and components important to safety, to design and characterization of barriers important to waste isolation, and to related activities. These activities include, among others, site characterization; acquisition, control, and analysis of samples and data; tests and experiments; scientific studies; facility and equipment design and construction; and performance confirmation (*see* 10 C.F.R. § 63.142(a)). DOE is required to establish its QA program compliant with the requirements of Section 63.142 at the earliest practicable time and must carry it out throughout the life of the facility (10 C.F.R. § 63.142(c)). 10 C.F.R. Part 63 Subpart G prescribes the myriad exacting components of an adequate QA program with which DOE must comply as a prerequisite to receiving a construction authorization from NRC.

The regulatory prerequisite components include: regular reviews of the status and adequacy of the QA program; control conditions, including appropriate equipment and suitable environmental conditions, such as adequate cleanness; assurance that applicable regulatory requirements, design basis, and other requirements necessary to assure quality are suitably included or referenced in the documents for procurement of material, equipment, and services, whether purchased by the licensee or applicant or by its contractors or subcontractors, including the requirement that contractors or subcontractors provide a QA program consistent with Subpart G; measures established to assure that purchased material equipment and services, whether purchased directly or through contractors or subcontractors, conform to the procurement documents; appropriate provisions for source supplier evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products on delivery; assessment of the effectiveness of quality control by contractors and subcontractors; inspection of activities affecting quality to verify conformance with instructions, procedures, and drawings performed by individuals other than those who performed the activity being inspected; measures taken to assure that conditions adverse to quality are promptly identified and corrective action taken to preclude repetition; and the maintenance of records sufficient to furnish evidence of successful implementation of activities affecting quality (*see* 10 C.F.R. §§ 63.142(a), (b), (c), (c)(2), (c)(4), (e), (h), (h)(1), (h)(3), (k), (r), and (s)).

DOE acknowledges that the requirements of the QA program are equally applicable to DOE's contractors and suppliers for repository design and construction activities (SAR Section 5.0).

DOE also committed in its License Application (SAR 5.1) to address each of the acceptance criteria in NUREG-1804 Rev. 2 for QA requirements. DOE knew when it made this commitment that NRC was required to evaluate the acceptability of the QA program by, among other things, the assessment of **ongoing** QA program activities and the evaluation of whether DOE is capable of implementing the complex QA responsibilities required of an effective QA program. Some of the component parts of that capability which NRC must review and confirm (and which DOE has committed to implement) include:

- assuring that verification of conformance to established requirements is accomplished by individuals or groups within the QA organization that do not have direct responsibility for performing the work being verified (NUREG-1804 Rev. 2 at 2.5-7);
- assuring that DOE must apply the controls of its QA program, *inter alia*, to site characterization, acquisitions and analyses of samples and data, tests and experiments, scientific studies, facility and equipment design and construction, and performance confirmation (NUREG-1804 Rev. 2 at 2.5-8);
- assuring that the development, control, and use of computer software supporting a safety or waste isolation function is conducted in accordance with the QA program (NUREG-1804 Rev. 2 at 2.5-8);
- assuring that quality-related activities, such as design and procurement, initiated before the NRC issuance of a license are controlled under an NRC-approved QA program in accordance with the requirements of 10 C.F.R. Part 63 Subpart G (NUREG-1804 Rev. 2 at 2.5-12);
- assuring that procurement documents require contractors and subcontractors to provide an acceptable QA program (NUREG-1804 Rev. 2 at 2.5-22);

- assuring that procurement documents include a statement of work (SOW) to be performed by the contractor containing the myriad requirements of the work or service to be performed (NUREG-1804 Rev. 2 at 2.5-22);
- assuring that suppliers' activities be verified to assure conformance to purchase order requirements and to QA requirements (NUREG-1804 Rev. 2 at 2.5-24);
- assuring that selection of suppliers is documented (NUREG-1804 Rev. 2 at 2.5-24);
- assuring that an effective Corrective Action Program has been established (NUREG-1804 Rev. 2 at 2.5-37); and
- assuring that conditions adverse to quality are identified and corrected promptly so that the QA organization is involved in concurrence of the adequacy of the corrective action (NUREG-1804 Rev. 2 at 2.5-37).

Table 1 contains only a small sample of internal and external QA inspections, assessments, audits, and critiques whose chronically unsatisfactory findings plagued DOE's QA program in the years leading up to its submission of its LA. Beginning with stop-work orders issued against each of its four major contractors in 1986 for their noncompliant QA programs, the QA audit paper trail found fault with virtually every aspect of DOE's QA program, including its failures with respect to calibration of test equipment, software, the quality culture of line personnel, and (presaging the most serious QA shortcomings which exist to this day) DOE's ineffective Corrective Action Program and its inadequate oversight of its contractors, subcontractors, suppliers, and sub-tier suppliers and its abdication of the necessary QA paper trail associated with their qualification and engagement. NRC's summary of the NRC/DOE Quarterly Management Meeting on April 19, 2002 (LSN# DEN001237845 at 1), reflects that Dr. Margaret Chu, Director of the Office of Civilian Radioactive Waste Management (OCRWM), **reiterated** her position stated at an earlier meeting that "The current YMP QA program is not ready for licensing." She focused on the issue that "problem identification must be accompanied by a dedicated approach to effective corrective action." While DOE expressed optimism at the meeting that "QA programmatic issues were moving in the right direction," NRC "took a more somber view," with its representative expressing concern over "why it has taken so long to start down a path toward resolution of the QA issues." Dr. Chu agreed that this was a legitimate concern. *Id*. at 4.

More recently, DOE Acting OCRWM Director Paul Golan, addressing a May 9, 2006 meeting with the NWTRB, explained that "We're working on improving the quality and the culture of the organization. We're going to have to demonstrate to the NRC . . . that our quality standards have been met, and that we're operating consistent with a quality program before we submit that license application to the NRC. And I would submit to you **we're not there yet**." NWTRB 5/9/2006 Tr. at 49-50 (LSN# NEV000003413).

Table 1

Date	Document Name	Description
06/10/1986	"Nuclear Waste: Repository Work Should Not Proceed Until Quality Assurance is Adequate," RCED-88-159, at 55 (LSN# NEV000004247)	• DOE issued a stop-work order on SAIC. Surveillance on March 13-19, 1986 found that SAIC was operating without approved quality assurance level assignments. • DOE issued a stop-work order on Los Alamos. Surveillance on February 26-27, 1986 found that LANL was operating without approved quality assurance level assignments or to unapproved quality assurance level assignments. • DOE issued a stop-work order on Lawrence Livermore. Surveillance on February 18-21, 1986 found that LLNL was operating without quality assurance levels assigned to work efforts. • DOE issued a stop-work order on Sandia. Surveillance on February 25-26, 1986 found that SNL was operating without approved quality assurance level assignments or to unapproved quality assurance level assignments.
03/07/1988	"Nuclear Waste: Repository Work Should Not Proceed Until Quality Assurance is Adequate," RCED-88-159, at 18, 37 (LSN# NEV000004247); "Nuclear Waste:	NRC identified broad concerns related to DOE's management approach to quality assurance. NRC believed that DOE's repository program was vulnerable unless weaknesses in DOE's quality assurance program were detected and corrected early. One of NRC's objections pertained to the adequacy of DOE's quality assurance program for site characterization work. NRC also found that DOE staff and contractors exhibited negative attitudes toward the function of quality assurance, noting that participants appeared to lack a full

Date	Document Name	Description
	Quarterly Report on DOE's Nuclear Waste Program as of 03/31/1988," RCED-88-163BR, at 2 (LSN# NEV000005433)	appreciation for what it took to get a facility licensed by NRC.
05/10/1988	"Forensic Review of USW-G4 Borehole Data as Existing Data in Licensing -An Investigative Report, with Enclosure" (LSN# DN2002168602) at 21	A "forensic" report on NNWSI drilling activities lays out a strategy for qualifying borehole data on the basis that there was a "project-wide failure in the *implementation* of an effective QA program." [p. 21, emphasis added]. "The QA questions raised over the activities associated with USW-G4 open up the real possibility that data derived from this borehole could be declared unqualified for use in licensing documents. Such data are fundamental to many of the major scientific questions regarding the suitability of Yucca Mountain as a geologic repository and the risk is that unqualified data would disqualify the site." "If this report accomplishes nothing else, it should serve as a warning to Project management that the first priority is to put in place a fully implemented and effective QA Program."
06/30/1988	"Nuclear Waste: Repository Work Should Not Proceed Until Quality Assurance is Adequate," RCED-88-159, at 62 (LSN# NEV000004247)	An OCRWM letter of this date to USGS stated that preliminary audit results indicated that USGS work "is not being performed in the manner necessary for the nuclear licensing environment." The recent deficiencies "reflect a fundamental and continuing problem in the attitude of some USGS personnel regarding quality assurance requirements."
09/29/1988	"Nuclear Waste: Repository Work Should Not Proceed Until Quality Assurance is Adequate," RCED-88-159, at 19, 32 (LSN# NEV000004247)	NRC identified a significant number of weaknesses in DOE’s quality assurance program indicating that problems were widespread throughout the quality assurance program. The need to implement effective quality assurance programs was especially important because of DOE’s reliance on contractors.

Date	Document Name	Description
09/1989	"Nuclear Waste: Quality Assurance Auditors Need Access to Employee Records," RCED-91-7, at 5 (LSN# NEV000003790)	None of DOE's quality assurance programs met NRC's requirements at this time.
10/1994	"Yucca Mountain: Quality Assurance at DOE's Planned Nuclear Waste Repository Needs Increased Management Attention," GAO-06-313, at 15 (LSN# NEV000003795)	NRC found problems with QA, particularly with the site contractor's ability to effectively implement **corrective actions** and DOE's ability to **oversee** the site **contractor's** QA program.
09/04/1996	"Department of Energy: Observations on the Future of the Department," T-RCED-96-224, at 7-8 (LSN# NEV000005434)	DOE had a long history of management problems and at the core of many of these problems was its weak oversight of more than 110,000 contractor employees who performed nearly all of the Department's work. These contractors got paid even if they performed poorly, and DOE oversaw them under a policy of "least interference." Historically DOE was unsuccessful in managing its many large projects, referred to as "major acquisitions"– those costing $100 million or more and which were important to the success of its missions. Since 1980, DOE was involved with more than 80 major acquisitions and many more of these projects were terminated prior to completion than were actually completed, and many had large cost overruns and delays.
2001	"Nuclear Waste: Preliminary Observations on the Quality Assurance Program at the Yucca Mountain Repository," GAO-03-826T, at 4 (LSN# NEV000003720); "Yucca Mountain: Quality Assurance at DOE's Planned Nuclear Waste Repository Needs	Model validation and software development problems resurfaced. New QA audits found that project personnel had not followed the required procedures for model development and validation or established a timeline for completing the models. These audits also identified that project personnel had not followed the software development process, prompting a prohibition on further software development without prior management approval. DOE attributed the recurrence to ineffective procedures and corrective actions, improper implementation of quality procedures by line managers, and personnel who feared reprisal for expressing quality concerns. According to DOE, the significance of these new observations was compounded by their similarity to

Date	Document Name	Description
	Increased Management Attention," GAO-06-313, at 15 (LSN# NEV000003795)	those problems previously identified. Recognizing a need to correct these recurring problems, DOE conducted a comprehensive root analysis.
06/2001	"Yucca Mountain: Persistent Quality Assurance Problems Could Delay Repository Licensing and Operation," GAO-04-460, at 10-11 (LSN# NEV000004130)	DOE was unable to close a June 2001 software corrective action report because auditors in 2003 found several ineffective software processes similar to previously identified problems, indicating that previous actions were ineffective in correcting the problems.
07/2002	"Nuclear Waste: Preliminary Observations on the Quality Assurance Program at the Yucca Mountain Repository," GAO-03-826T, at 4-5 (LSN# NEV000003720)	DOE provided NRC with a revised management plan to correct its QA problems, including problems with scientific models and software codes which also included performance measures to assess the effectiveness of the actions. DOE identified a total of 72 actions needed to correct the QA program. – 35 to address the five key areas, 12 to address model development issues, and 25 to address software development issues.
Early 2003?	"Nuclear Waste: Preliminary Observations on the Quality Assurance Program at the Yucca Mountain Repository," GAO-03-826T, at 5 (LSN# NEV000003720)	DOE reported that the project still lacked complete and useful performance measures and stated its intention to have the appropriate performance measures in place by September 2003.
03/2003	"Nuclear Waste: Preliminary Observations on the Quality Assurance Program at the Yucca Mountain Repository," GAO-03-826T, at 5 (LSN# NEV000003720)	DOE issued a "stop-work" order preventing any further use of a procedure intended to help improve DOE and contractor QA procedures. According to DOE, they canceled the use of the procedure and reverted back to the existing procedure.

Date	Document Name	Description
04/2003	"Nuclear Waste: Preliminary Observations on the Quality Assurance Program at the Yucca Mountain Repository," GAO-03-826T, at 5 (LSN# NEV000003720)	An NRC official commented that the QA program still had not produced the outcomes necessary to ensure the program was compliant with NRC requirements.
05/28/2003	"Nuclear Waste: Preliminary Observations on the Quality Assurance Program at the Yucca Mountain Repository," GAO-03-826T, at 5-6 (LSN# NEV000003720)	Whether DOE can correct its QA problems in time to meet its milestone for submitting an application that was acceptable to NRC was not clear. DOE's unsuccessful efforts to address recurring QA problems, the identification of new problems since the issuance of its 2002 improvement plan, and NRC's recent comment that DOE's QA plan had yet to produce outcomes necessary to ensure that the program met NRC requirements left the future success of the QA program uncertain.
Late 2003	"Yucca Mountain: Persistent Quality Assurance Problems Could Delay Repository Licensing and Operation," GAO-04-460, at 12 (LSN# NEV000004130)	Three of four management assessments identified significant continuing problems with the delineation and definition of roles and responsibilities for carrying out the QA program.
04/2004	"Yucca Mountain: Persistent Quality Assurance Problems Could Delay Repository Licensing and Operation," GAO-04-460, at 21-22 (LSN# NEV000004130)	Because of the limitations noted in the Longenecker review, DOE had not yet evaluated the effectiveness of corrective actions. GAO concluded that despite working nearly three years to address recurring QA problems, recent audits and assessments found that problems continued with data, models and software, and that management weaknesses remained. GAO concluded that recurring problems could create the risk of introducing unknown errors into the design and construction of the repository that could lead to adverse health and safety consequences. Because of its lack of evidence that its actions were successful, DOE was not yet in a position to demonstrate to NRC that its QA program could ensure the safe construction and long-term operation of the repository. GAO recommended that DOE SECY direct the Director, OCRWM, to revise the performance goals in the 2002 action plan to include quantifiable measures of

Date	Document Name	Description
		the performance expected and time frames for achieving and maintaining this expected level of performance and close the 2002 plan once sufficient evidence showed that the recurring QA problems and management weaknesses that were causing them were successfully corrected.
03/2005	"Yucca Mountain: Quality Assurance at DOE's Planned Nuclear Waste Repository Needs Increased Management Attention," GAO-06-313, at 19, 33, 35 (LSN# NEV000003795)	Emails from USGS employees written between May 1998 and March 2000 implying that employees had falsified documentation to avoid QA standards were discovered. After announcing the discovery of USGS emails suggesting possible violation of QA requirements, including the falsification of records, DOE took steps to address lingering concerns about the adequacy of the scientific work related to the flow of water into the repository and whether similar QA problems were evidenced in other emails relevant to the licensing application. NRC encouraged DOE to take the time and actions necessary to fully and adequately resolve these and other QA issues.
08/2005	"Yucca Mountain: DOE's Planned Nuclear Waste Repository Faces Quality Assurance and Management Challenges," GAO-06-550T, at 14 (LSN# NEV000003778)	After observing a DOE QA audit of LLNL THC Seepage Model, NRC staff expressed concern that humidity gauges were not properly calibrated. According to an NRC official, NRC communicated its concerns on the LLNL audit findings to DOE and BSC project officials on six occasions between August and December 2005.
10/2005	"Yucca Mountain: Quality Assurance at DOE's Planned Nuclear Waste Repository Needs Increased Management Attention," GAO-06-313; at 35 (LSN# 000003795); "Yucca Mountain: DOE's Planned Nuclear Waste Repository Faces Quality Assurance and Management Challenges," GAO-	DOE began to develop an action plan for reviewing, validating, augmenting and replacing USGS work products that had come under scrutiny. However, in December 2005 and again in February 2006, some project work was stopped due to continuing QA problems.

Date	Document Name	Description
	06-550T, at 2 (LSN# NEV000003778)	
11/09/2005	"Yucca Mountain: Quality Assurance at DOE's Planned Nuclear Waste Repository Needs Increased Management Attention," GAO-06-313, at 34 (LSN# 000003795)	The DOE IG found emails containing possible conditions adverse to quality among ten million that had already been reviewed for relevancy to the licensing process. Further, a number of them were deemed not relevant to the licensing process. The IG recommended that OCRWM (1) expand its quality-assurance-related search effort to include a more comprehensive review of the ten million archived emails to assure that all conditions adverse to quality were appropriately identified, investigated, reported and resolved and (2) ensure that current and future emails were reviewed for possible conditions adverse to quality, and that such conditions be appropriately addressed under the Corrective Action Program.
02/07/2006	"Yucca Mountain: DOE's Planned Nuclear Waste Repository Faces Quality Assurance and Management Challenges," GAO-06-550T, at 14 (LSN# 000003778)	Stop-work order issued by BSC on the use of Visaila relative humidity/temperature probes affecting the LLNL THC Seepage Model scientific work due to concerns that QA requirements had not been followed and the length of time it took top management to become aware of the issue. In August 2005, NRC observed a DOE QA audit at LLNL and expressed concern that humidity gauges used in scientific experiments at the project were not properly calibrated – an apparent violation of QA requirements. This delay was an example of the project's management tools not being effective in bringing QA problems to top management's attention.
03/2006	"Yucca Mountain: Quality Assurance at DOE's Planned Nuclear Waste Repository Needs Increased Management Attention," GAO-06-313, at 21, 42 (LSN# 000003795)	After more than twenty years of project work, DOE again faced substantial QA and other challenges to plans to submit a fully defensible license application to the NRC. DOE's Initiatives raised concerns about five key areas of management weakness adversely affecting the implementation of QA requirements.
Spring 2006	"Yucca Mountain: DOE Has Improved its Quality Assurance Program, But Whether its Application for a NRC License Will be	DOE requested that a team of external QA experts review the performance of the QA program. The experts concluded that 8 of the 10 topics they studied had not been effectively implemented. The team found the corrective action program did not ensure that problems were either quickly or effectively resolved. A follow-up DOE root cause analysis report concluded that **the**

Date	Document Name	Description
	High Quality is Unclear," GAO-07-1010, at 19 (LSN# NEV000005413)	**corrective action program was ineffective primarily because senior management had failed to recognize the significance of repeated internal and external reviews and did not aggressively act to correct identified problems and ensure program effectiveness**. In response, DOE revised the CAP to change organizational behaviors and provide increased management attention.
12/2006	"Yucca Mountain: DOE Has Improved its Quality Assurance Program, But Whether its Application for a NRC License Will be High Quality is Unclear," GAO-07-1010, at 19 (LSN# NEV000005413)	External review of the QA program found that OCRWM staff had focused its efforts on trying to downgrade the significance of condition reports to deflect individual and departmental responsibility, rather than ensuring that the underlying causes and problems were addressed.
01/19/2007	"Yucca Mountain Project: Information on Estimated Costs to Respond to Employee E-Mails that Raised Questions about Quality Assurance," GAO-07-297R, at 2 (LSN# NEN000000578)	GAO estimated costs for DOE's response to the USGS employee email issue: review of project emails and other relevant documents to determine the extent and nature of problems similar to those suggested by the USGS emails – $4.2 million; scientific rework related to the USGS water infiltration analysis – $21.1 million; management and QA training for personnel – $340,000.
06/2007	"Yucca Mountain: DOE Has Improved its Quality Assurance Program, But Whether its Application for a NRC License Will be High Quality is Unclear," GAO-07-1010, at 15 (LSN# NEV000005413)	OCRWM project managers told GAO that because QA rules were not followed at LLNL [THC Seepage Model, gauges were not properly calibrated], DOE could not use this scientific work to support the license application.
08/2007	"Yucca Mountain: DOE Has Improved its Quality Assurance Program, But Whether its	DOE had again implemented changes to its corrective action program, the broader system for recognizing problems and tracking their resolution. It was one of the key elements of the project's QA framework.

Date	Document Name	Description
	Application for a NRC License Will be High Quality is Unclear," GAO-07-1010, at 19 (LSN# NEV000005413)	
08/2007	"Yucca Mountain: DOE Has Improved its Quality Assurance Program, But Whether its Application for a NRC License Will be High Quality is Unclear," GAO-07-1010, at 20-21 (LSN# NEV000005413)	DOE's root cause analysis team found no apparent widespread or pervasive pattern of a negative attitude toward QA or willful noncompliance with QA requirements. Analysis did find that OCRWM senior management failed to (1) hold USGS personnel accountable for the quality of the scientific work; (2) fully implement QA requirements; and (3) effectively implement the corrective action program.

Table 2 contains just a sample of QA evaluations or surveillances or audits assessing the **current** status of DOE's deficient QA, **after** the time it filed its LA on June 3, 2008. The documents and findings enumerated in Table 2 particularly illustrate the poor QA performance of DOE and its contractors, especially in the areas of Corrective Action Program and oversight of contractors/suppliers, in the face of newly adopted procedures and programs supposedly designed to fix those very problems, symptomatic of DOE's QA shortcomings for the last two decades. The OQA organization demonstrates an ability to locate and articulate problem areas, but DOE's lack of quality culture results in the deficiencies not being timely corrected, huge corrective action backlogs, and repetition of the same kinds of deficiencies year after year. As reflected in DOE's own documents, one of its errant responses to the problem has been to remove corrective action oversight responsibilities from the QA program and return them to the very line organizations whose insensitivity to quality work spawned the problems in the first place.

Table 2

Date	Document Name	Description
07/11/2008	"Review of Oversight of the OCRWM Corrective Action Program" (4/1/2008-6/30/2008) (LSN# DEN001600603)	• p. 2 The scope of this independent surveillance of the CAP included ensuring that effective corrective actions are taken to address the problems identified and to prevent recurrence. • p. 3 The QA CAP oversight team has developed a backlog of CRs to review from the last three months. • It was noted that there continues to be some longstanding poor performance CAP PIs (performance indicators) mainly in the DOE organization. • p. 5 "DOE continues to struggle with CAP implementation performance." • p. 5-6 As part of the CAP oversight team's effort, the team conducted a surveillance on the closure of CR-9774 ("Ineffective Implementation of the CAP"); as a result of this evaluation, the team identified four more CRs relative to the closure of CR-9774. • p. 8 Other conclusions included: "The timeliness and completeness of corrective action closeouts require the most immediately management attention." "The focus of this attention needs to be on CAP timeliness, completeness, and improvement in overall CAP performance accountability." Also, "improve the timeliness of corrective action implementation."
07/10/2008	"Effectiveness of the Quality Assurance Program Implementation OQA2008-02" (LSN# DEN001603133)	In a quality assurance report signed on July 10 (a month after the LA was filed), QA "chief" Larry Newman admitted: • "QA has not provided effective oversight of the self-assessment program." • "Numerous condition reports were written to address issues raised by the 2006 NEI Independent Assessment of Quality Assurance [i.e., two years before the LA]; however, some of those issues . . . continue to be present." • "A culture issue exists within QA. . . . The QA organization is still not aligned internally. Confusion exists with the direction that QA is taking." • "During the self-assessment it was acknowledged by QA and YMP management that a considerable effort remains to sustain Corrective Action Program effectiveness. The timeliness and completeness of corrective action close-outs require the most immediate management attention."

Date	Document Name	Description
06/30/2008	"Yucca Mountain Project Quality Performance Assessment Report (QPAR)" (May 1 to May 31, 2008) (LSN# DEN001598783)	Published June 30, 2008, a month after LA, this document defines DOE's status as of the filing date. Some of its key findings: • Work remains to be done in some areas to bring the Corrective Action Program to the next level of performance, most particularly on the timeliness of corrective action close-outs. • Issue resolution timeliness remains a problem area particularly in DOE and SNL-LL, and requires continued management attention. • Timely corrective action completion and closure continue to require management attention across the project. • The timeliness and completeness of corrective action close-outs require the most management attention. More urgency and accountability is needed. • DOE's overall Corrective Action Program performance index as of the end of May 2008 was rated 59.6 percent (defined as "**less than adequate** performance"). • SNL-LL (Sandia-Livermore) overall CAP performance index as of the end of May 2008 was 68.3 percent (also defined as "**less than adequate** performance"). Moreover, the SNL-LL index was characterized as "**declining**" rather than improving. • Issue resolution timeliness has slightly improved, but remains a problem, particularly in DOE and SNL-LL, which continue to show **unsatisfactory** performance in at least two of the six CAP timeliness performance measures. • Overall project timeliness in completing CRs (Condition Reports), based on original completion dates, has further declined from 37.9 percent in April 2008 to **20.3 percent** in May 2008, against the established goal of 95 percent. (Performance in DOE improved in this area, but declined in Bechtel and Sandia.) • The average age of QA identified significant issues has increased from 648 days last month to 672 days during this month, remaining well above the 90-day goal. • A chart detailing the 20.3 percent overall project timeliness in completing Condition Reports breaks down the figure by organization: DOE 29.4 percent; Bechtel 23.1 percent; Sandia/Livermore 15.4 percent.
07/01/2008	"Construction Management and Site	This document was issued July 1, 2008, a month after the LA was filed. Some of its key findings include:

Date	Document Name	Description
	Operations Office Focused Self-Assessment 'Effective Implementation of OCRWM Corrective Action Program'" (May-June 2008) (LSN# DEN001599193)	• A review of Corrective Action Program (CAP) database metrics disclosed: o With respect to the identification of new Condition Reports, the performance indicators ranged from **less than adequate to unsatisfactory**. Except for **one isolated incident** where the performance indicator showed **adequate**, the remaining performance indicators are less than adequate (13) and unsatisfactory (2), indicating that improvements are needed. o Self-identification of problems - performance indicators ranged from unsatisfactory to adequate. While seven performance indicators showed **adequate**, there were four performance indicators that were unsatisfactory and seven performance indicators that were less than adequate. o Line identification of problems - performance indicators ranged from unsatisfactory to sustained adequate. There was an isolated sustained **adequate performance** indicator, but otherwise, it was split between meets goal (6), unsatisfactory (6), and less than adequate (5). The predominate performance indicators are either unsatisfactory or less than adequate. • The requirement for a "previous occurrence review" became effective on 10/29/2007. The audit team reviewed five CRs for the adequacy of the "previous occurrence review." In four of the five, a "previous occurrence review" was simply not found at all. • A sample of nine Condition Reports (CRs) were reviewed to assess the effectiveness and adequacy of "interim corrective actions." o The CRs had been open for a period in excess of 160 days, and were examined to gauge if interim actions were put in place to address the identified deficiencies. o Of the nine CRs evaluated, three had no interim actions taken, where interim actions "should have been conducted." o One of those CRs involved worker safety, and the audit team found that the justification provided under a "worker safety and health program review" provided "**NO** technical data to support the conclusion that the overall risk to worker safety and health is negligible."

Date	Document Name	Description
		• The audit report lists some 15 separate Condition Reports which were issued as a result of OCRWM's self-assessment of its Corrective Action Program (CAP), this coming after it had filed its License Application.
07/31/2008	"DOE Quality Performance Assessment Report (April 1 to June 30, 2008)" (LSN# DEN001603345)	• Report is signed off by OQA Director Newman, and lists the Corrective Action Program as the number one problem area in quality assurance, specifically focusing on the continuing problem with timely corrective action completion and closure. • Newman provides statistics illustrating that, with respect to their CAP performance indices (separately calculated by organization), DOE's has declined, Bechtel's has declined, and the project overall has declined, with only a slight improvement shown by Sandia. • DOE rates overall CAP performance pattern by colors, with green representing adequate performance for three straight months: neither DOE nor Bechtel nor Sandia nor the project as a whole is rated green, with DOE's performance dropping from yellow (59.6%) to red (44.8%).
08/01/2008	"Office of the Chief Scientist Self-Assessment of the OCRWM Control Procedures to Identify Schedule-Driven Processes: A Focused Self-Assessment Report" (LSN# DEN001603571)	• The purpose of the report is to examine all OCRWM administrative and line procedures, to determine which ones contain schedule deadlines to be met according to the procedure. • Those procedures which require performance in adherence to one or more deadlines are looked at more closely, to determine whether the deadlines are required regulatory or are merely, in DOE's words, "SME" (Senior Management Expectations). • Those which are merely SME are then reconsidered with Russ Dyer (DOE Chief Scientist) then making a recommendation with respect to revising the schedule requirement **out** of the procedure. • Dyer's rationale for eliminating schedule deadlines is "to reduce adverse impacts of existing prescribed schedule constraints on the efficient conduct of business within the OCRWM program." • In stark contrast to the reality of the problems besetting the Corrective Action Program, Dyer reflects DOE's mindset by recommending modification of schedule deadlines prescribed by the procedures for "management of conditions adverse to quality for external organizations" and corrective action

Date	Document Name	Description
		requirements in the OCRWM procedure for safety & health program inspection. • In recommending modification or deletion of all of the schedule deadlines for corrective action in these areas, Dyer's justification is "schedule related issues in the corrective action program common a year ago are less of a concern today." One could not seriously contend this to be true in view of the myriad audits and assessments during this period critical of the timely completion of corrective actions in the Corrective Action Program, including the Quality Performance Assessment Report signed off on just the day before by OQA Director Newman.
08/07/2008	"OCRWM Corrective Action Program Condition Screening Team" (LSN# DEN001601246)	• DOE adopts another "get-well" program for its CAP, with a whole new group with a whole new membership. • It is assigned the task of ensuring prompt and accurate corrective action when Condition Reports arise. • The CST (Condition Screening Team) is established to support management in the effective implementation of the Corrective Action Program. • (All this is a tacit admission by DOE that, as of two months after the LA, its CAP is still in total disarray and DOE is throwing a new fix-it program at the problem.)
08/22/2008	"Bechtel Quality Assurance Surveillance Report BQA-SE-08-030" (LSN# DEN001600946)	• Surveillance of a supplier (American Tank and Fabricating Company) quality assurance program. • Contract was fabrication of waste package closure mockup. • The surveillance was performed to document verification of the activities associated with the first welding operation of the waste package closure mockup. • The surveillance found flow meters used during the welding process improperly calibrated. • The flow meter was sent to an unapproved supplier for calibration. • The meter was delivered to the unapproved supplier on July 24, 2008, while procurement documentation was not generated until August 8, 2008. • Stork Herron Material Testing issued a calibration certification on August 11, 2008. In fact, Stork Herron Material Testing was never in possession of the flow meter, yet issued a calibration certificate indicating that the calibration activity was performed in accordance with their quality program, including 10 C.F.R. Part 21.

Date	Document Name	Description
		• Surveillance found that this incident indicates a serious breakdown in the implementation of the AT&F quality assurance program. • The incident was identified as a significant condition adverse to quality, and a stop work was initiated against all quality-related fabrication activities of the waste package closure mockup. • AT&F developed a project-specific procedure identifying the cleaning processes employed prior to and after welding. This procedure was not submitted to BSC for approval prior to the beginning of manufacturing. This is considered a condition adverse to quality. • Bechtel's applicable specification provided "subcontractor shall select sub-tier suppliers based on formal audit and evaluation of the sub-tier supplier's capability to provide items and services in accordance with the contractor's procurement documents and placement of the sub-tier supplier on subcontractor's supplier list." Contrary to this requirement, AT&F utilized an unapproved supplier to calibrate the argon flow meter used during the welding operations.
07/21/2008	"Quality Assurance Internal Audit IA-08-07 Checklist" (LSN# DEN001599173)	• Implementation of QARD is the focus. • Found that procurement review record dated 11/1/2006 for PO-704343 to Northwest Geophysical Associates indicates a "Q" procurement requiring approval by audit and includes a QA requirement in statement of work (SOW) that an audit will be performed prior to start of work. Supplier was not on qualified supplier list and no audit was performed. • Found that SOW reviews to ensure correct translation to the ORACLE system are being performed by the lead lab procurement coordinator, but the reviews are not being documented. The consequence of this happening could be a complete redo of the work by the supplier, unqualified data being submitted erroneously, or errors caused by incorrect or missing technical requirements. • Found that the lead lab procurement process does not address all applicable QARD requirements for documents associated with purchase orders. • Found there are no roles, responsibilities or procedural controls for reviews to ensure the actual contract document (the purchase order) that transmits technical and quality requirements to suppliers matches the reviewed and approved SOW.

Date	Document Name	Description
		• The lead lab procurement process is not in full compliance with QARD requirements, which could result in inadequate quality work being performed. • (p. 15) Found that numerous suppliers had no audit performed on them prior to the audit due date listed on the qualified suppliers list. Included critical suppliers such as Oak Ridge National Lab, AREVA, *etc.* • (p. 16) Overall maintenance of the OCRWM qualified suppliers list (QSL) is inadequate.
07/29/2008	"Apparent Cause Analysis Report (CR #12353): QSL (and Supplier) Maintenance Issues" (LSN# DEN001602079)	• The problem statement for this Condition Report observed that some suppliers were not audited or evaluated when due, supplier evaluation reports (SERs) were not completed as required, the QSL was not updated to accurately reflect the approved supplier evaluation reports; also, errors were found on the OCRWM QSL along with a failure to audit or evaluate qualified suppliers which it was deemed could impact the quality of products or services since the list is used to place orders and approve suppliers.
08/19/2008	"Condition Adverse to Quality RDH-6 Problem Statement" (LSN# DEN001599808)	• Lead lab management attention is needed to ensure that the procurement process is adequately described, formally documented, and adequate records are maintained. It is recommended that OQA be involved in the CR planning and corrective action implementation. • Recommendation – institute immediate corrective actions to document that QA and technical requirements contained in previously processed purchased orders align with the SOW (statement of work) documents that were reviewed and approved. • Recommendation – revise the appropriate lead lab procedures to ensure that adequate documentation exists, that the reviewed and approved SOW matches the technical and quality requirements reflected in the purchase order sent to suppliers.
07/15/2008	"OCRWM Report for Audit IA-08-07 of the QA Program Implementations of QARD (by OCRWM, Bechtel, and Sandia)" (April 28 - July 8, 2008) (LSN# DEN001599605)	This assessment includes a period of about a month before the LA issuance and about a month after, and was published on July 15, 2008. Some of its key findings include: • The primary objective of the audit was to determine whether OCRWM and principal contractors were effectively implementing the requirements in the QARD for **procurement document control** and control of purchased equipment. Serious deficiencies were found with supplier documentation. The audit

Date	Document Name	Description
		team issued a "QA organization finding" stating that all applicable QARD and procedure requirements are **not** being followed specific to the supplier qualification process. A review of the supplier files reveals that not all suppliers were audited or evaluated when required. • The audit found that the actual Sandia purchase orders and amendments did not reflect the same technical and quality requirements reviewed and approved in the "statement of work" (SOW), the primary document underlying the purchase in question. The audit team found that Sandia would develop a SOW for technical and quality requirements, but entered it into an unqualified database to produce the purchase order. The purchase order, not the SOW is then forwarded to the supplier. • "The lack of purchase order and lack of evidence of actual transmittal of quality and technical requirements could impact Sandia's ability to provide QA records that may be needed during the licensing period." An example was cited during the audit whereby the requirements in the SOW were **different than** those in the purchase order transmitted to the supplier. As a result of this issue, the procedure controls in the lead lab are not considered adequate. • The audit team examined procurement documents at DOE, Bechtel, and Sandia, and found "the lead lab procurement process does not provide documented reviews, approval, or retention of the actual Sandia Corporation (subcontractor to SNL) issued purchase order." Additionally, the purchase orders are not classified as OCRWM QA records retrievable from the RPC (Requirements Package Checklist). • The audit team reviewed SERs (Supplier Evaluation Reports) initiated by DOE, Bechtel, and Sandia and found: o Suppliers were not audited by the required audit due date. o Annual evaluations were not performed by due dates, and no evidence that evaluations included recent supplier audit results. o The QSL (Qualified Supplier List) database was changed without an approved SER (Supplier Evaluation Report). o Several errors were identified when comparing the QSL to the SER. (A Condition Report was issued as

Date	Document Name	Description
		a QA finding to document these conditions adverse to quality.) • The recent accumulation of errors and implementation of the QSL maintenance process and weaknesses in the program warrants a need for the QA organizations to ensure that the roles and responsibilities for maintaining the QSL are clearly defined and consistently implemented by all QA organizations.
08/13/2008	"Bechtel QA Surveillance BQA-SI-08-065" (LSN# DEN001600918)	• Surveillance concerned control of purchased items and services, supplier evaluations, and maintenance of supplier list. • The surveillance concluded implementation of requirements unsatisfactory; and effectiveness of implementation unsatisfactory. • "It is concluded that the environmental safety and health (ES&H) organization has not satisfactorily implemented requirements specified in the QMD and implementing procedures for the procurement of analytical services. Specifically, laboratories that provide analytical services to the ES&H organization have not been evaluated in accordance with requirements to perform this work. Additionally, laboratories providing analytical services have not been placed on the supplier list." • A Condition Report was initiated to address the condition adverse to quality regarding the procurement of analytical services by the Bechtel ES&H organization. • DOE's QA requires that verification and evaluation of suppliers providing analytical services has been performed: contrary to this requirement, three laboratories have been used for the performance of analytical services; upon review it was determined that none of these three laboratories was evaluated as required. • DOE QA also requires that the performance of suppliers be evaluated and documented on a periodic basis: contrary to this requirement, no evaluation of the performance of the same three laboratories (Datakim Laboratories, EFFEX Analytical Services, and Armstrong Forensic Laboratory, Inc.) had been conducted as required. • The Bechtel QA organization was not even informed of the services being provided by the three laboratories. • DOE QA requires that a supplier list be maintained,

Date	Document Name	Description
		including any suppliers providing analytical services: contrary to this requirement, the same three analytical service providers were not evaluated and placed on the suppliers list as required. • DOE QA requires a formal acceptance of services take place for services provided by analytical laboratories: contrary to this requirement, the products of the three labs in question were not evaluated for acceptance, including the completion of acceptance reports as required by QA-PRO-1071.
08/12/2008	"Bechtel QA Surveillance BQA-SI-08-065" (LSN# DEN001600918)	• In a sample size of three, all three suppliers checked were found to be unapproved. • The laboratories performing analysis of samples in support of ES&H work activities had not been evaluated, and were not on the approved suppliers list. • The audit recommended that an extent of condition be performed to evaluate the length of time that the Bechtel ES&H organization has been out of compliance and determine if analytical services have been provided by other laboratories.
08/19/2008	"OCRWM Supplier Audit SA-08-29 (Project Management and Oversight of Engineering Services at AREVA Federal Services, LLC)" (LSN# DEN001601470)	• AREVA is subcontracting all TAD canister system engineering and design work to Transnuclear, an AREVA company, through the procurement process. • AREVA's project plan did not clearly identify which QA program (AREVA or Transnuclear) applies to each part of the scope of work in the DOE contract, does not explain the contractual interface between AREVA and Transnuclear, and does not contain all required approvals on the plan. • Transnuclear was added to the AREVA approved supplier list in accordance with a procedure requiring a supplier evaluation to be performed. AREVA did not comply with this procedure and could not provide objective evidence of a supplier evaluation or a documented review of the Transnuclear QA program. • AREVA is using AREVA-NP (a subsidiary) for QA records storage and AREVA-NP is not on the AREVA approved supplier list for this scope of work. • AREVA's audit team was not sufficiently independent (i.e., the same people were evaluating work done as were directly involved in the performance of the work).
07/31/2008	"Bechtel Quality Assurance Surveillance No.: BQA-SI-08-054 (July	• This surveillance by Bechtel investigated the proper processing of Design Change Requests (DCRs), particularly those which impact the License Application.

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	31, 2008)" (LSN# DEN001601221)	• The surveillance found: "The examined activity integrates LA affected design change control processes between Bechtel Engineering, Bechtel Repository Project Management Integration, and DOE. This surveillance identified six issues adverse to quality regarding Bechtel Engineering noncompliance with the design change control process and Bechtel Repository Project Management Integration noncompliance with the License Application change control process and TMRB (Technical Management Review Board) operations."
		• The surveillance found: "Conclusion: The final results of Bechtel Surveillance BQA-SI-08-054 identified: (1) ineffective implementation of the Bechtel Engineering design change control process; (2) ineffective implementation of the Bechtel RMP licensing TMRB process; (3) confusing interface implementing steps; and (4) poor recordkeeping practices."
		• The surveillance summary reflected:
		  o Adequacy of requirements: unsatisfactory
		  o Implementation of requirements: unsatisfactory
		  o Effectiveness of implementation: unsatisfactory
		• In one instance, 18 Document Change Requests (DCRs) were examined; 8 of them did not have the required signature indicating authorization to continue; and 16 of the 18 did not have the Technical Management Review Board information recorded after TMRB decision proposals were closed.
		• Another 18 DCRs examined reflected 16 which did not have the required signature indicating approval for work to proceed; and 16 of the 18 were also not registered as closed, as required.
		• In another group of 17 TMRB decision proposals reviewed, 14 were found to be unsatisfactory.
		• In another group of 18 DCRs examined, 8 did not include the required signature authorizing work to continue; 16 of the 18 did not have the TMRB disposition recorded.
		• In a different group of 18 DCRs reviewed, 16 did not receive project engineering approval for work to proceed; did not receive the engineering manager approval of the DCR; nor was necessary information forwarded to project document control.
		• In another sample of 17 DCRs, 14 were found not to meet requirements.

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		• Again, in another group of 17 DCRs, 14 TMRB decision proposals reviewed did not have the implementing actions recorded in the DCR. • Finally, in another group of 17 DCRs sampled by the surveillance team, 16 of the 17 did not meet requirements because the responsible manager signed off on all of them as implementation completed, prior to the requested change and other implementing actions actually being conducted.
08/13/2008	OCRWM "Report for Surveillance: Independent Assessment Issues" (June 25-July 25, 2008) (LSN# DEN001601259)	• This document was issued August 8, more than two months after the LA filing. • The purpose of the surveillance was to perform a review of three previous QA assessments to confirm corrective action had taken place. The three were a Quality Assurance Management Assessment done in 2007, an Independent Review Team (IRT) Assessment done in 2007, and an NEI Independent Assessment done in 2006. In other words, all the issues were on the table for a year or two before this evaluation was conducted. • No personnel were contacted by the review team. It based its review on a search of Corrective Action Program (CAP) records regarding the issues and recommendations identified in the aforementioned three QA assessments. • In its conclusion, OCRWM concludes: "The YMP inconsistently addressed problems identified by the three independent assessment teams (i.e., 2006 NEI, 2007 QAMA, and 2007 IRT)." • **About 35 percent of all the issues evaluated have not been effectively implemented.** • One major area in which a deficiency (CR 10174b) remained totally open was the criticism that "line management hasn't taken the next step in translating their expectations to assure that an effective safety culture (defined areas important to safety, important to waste isolation, and License Application/submittal) is implemented." • One of the so-called "closed-satisfactory" recommendations confirmed by this audit was: "OCRWM, BSC and SNL should evaluate their respective QA program plans and practices to identify responsibilities that have been assigned to the QA organization that potentially undermine line management responsibility and accountability for quality. Where such situations are identified, a strategy

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		for the smooth transition of the responsibility from the QA organization to the line organization should be developed and implemented." • Another recommendation "satisfactorily" implemented: "Discontinue 100 percent review by Office of Quality Assurance of all Condition Reports." • Another: "The Yucca Mountain QA organizations should remove themselves from inline procurement document reviews, turning the process over to the line organizations." • Another example of a recommendation "satisfactorily" implemented: "Close Condition Reports upon execution of the corrective actions as approved by the responsible line manager. Assign subsequent effectiveness assessments to the line organization. Eliminate QARD Section 16.2.5 and the associated actions in AP-16.1Q that require verification of corrective actions."
08/26/2008	Condition Report No. 10268 (LSN# DEN001601739)	• The CR lists seven different DOE procedures which do not meet the required QARD requirements and need to be redone.

A comprehensive and effective QA program is prerequisite to ensuring the health and safety of employees and the public and the protection of the environment, and the recurring problems evidenced in DOE's QA program up to this very day create the risk of introducing unknown errors into the design and construction of the repository that could lead to adverse health and safety consequences and dispel any suggestion that DOE has had in the past, does have presently, or has any reasonable expectation that it will have in the future, such an effective QA program at YMP.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the hollow speculation of SAR Subsection 5.0, 5.1, 5.1.2, and similar subsections and DOE's QARD (incorporated by reference in the License Application in Chapter 5), regarding DOE's high hopes for quality assurance (QA) in the future, because they ignore the facts that DOE has been and continues to be unable to implement an adequate QA program and that there exists no basis for a reasonable expectation that DOE will do so in the future.

NEV-SAFETY-04 - CONTENT OF QUALITY ASSURANCE PROGRAM

1. A statement of the contention itself

Legal issue: SAR Subsection 5.1.2, which states that the Quality Assurance Requirements and Description (QARD) addresses design, analysis, fabrication, construction and testing of the repository, fails to comply with applicable quality assurance criteria because the SAR does not address repository operation, permanent closure, and decontamination and dismantling of surface facilities.

2. A brief summary of the basis for the contention

DOE admits in SAR Subsection 5.1.2 that the QARD will be revised in the future to address future activities related to facility operations, permanent closure of the repository, and decommissioning and dismantling of the surface facilities; however, DOE is required to include in its safety analysis report a description of the quality assurance program to be applied to all structures, systems and components important to safety, all activities important to waste isolation, and all activities important to safety functions of those structures, systems, and components, specifically including operations, permanent closure, decontamination and dismantling of surface facilities.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the applicable NRC requirements application to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the quality assurance program

complies with the requirements of 10 C.F.R. Part 63, Subpart G. 10 C.F.R. § 63.21(c)(20) requires a description of the quality assurance program to be applied to the structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation, 10 C.F.R. § 63.142(a) (part of Subpart G) restates the requirements of 10 C.F.R. § 63.21(c)(20), and adds that DOE is required to include in its safety analysis report a description of the following quality assurance program activities (and how the applicable quality assurance requirements will be satisfied): site characterization; acquisition, control, and analyses of samples and data; tests and experiments; scientific studies; facility and equipment design and construction; facility operation; performance confirmation; permanent closure; and decontamination and dismantling of surface facilities. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.1, at 5.1-1, states that the QARD, which is specifically incorporated by reference in the license application, describes the requirements of the quality assurance program that apply to quality-related activities at the Yucca Mountain repository. SAR Subsection 5.1.2, at 5.1-1 and 5.1-2, states that for the design, analysis, fabrication, construction and testing of the repository the present revision of the QARD describes the quality assurance requirements and strategies that DOE is required to implement, and that the QARD will be revised at appropriate times to reflect future activities related to facility operations, permanent closure of the repository, and decontamination and dismantling of surface facilities. "Quality Assurance Requirements and Description, DOE/RW-0333P Rev. 20" (10/01/2008), LSN# DEN001574022 at 29-30,states in Subsection 2.2.2 that the QA program shall apply to all structures, systems and components

(SSCs) important to safety, design and characterization of barriers important to waste isolation, and related activities. Related activities are identified as including site characterization; acquisition, control, and analysis of samples and data; tests and experiments; scientific studies; performance of the pre-closure safety analysis, total system performance assessment (post-closure safety analysis), and qualification of their inputs; and performance confirmation. *Id*. at 30. Since the QARD does not apply the QA program to facility operation, permanent closure, or decontamination and dismantling of surface facilities, and since the SAR states that the QARD will be revised in the future in application to facility operations, permanent closure of the repository, and decommissioning and dismantling of the surface facilities, the LA fails to comply with the requirements of 10 C.F.R. §§ 63.21(c)(20) and 63.142(a), and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.1.2, which in turn relies on DOE reference document DEN001574022, which states that states that the QA program only addresses design, analysis, fabrication, construction and testing for the Yucca Mountain repository but will be revised in the future to address facility operation, permanent closure, decontamination and dismantling of surface facilities. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.1.2 is materially incomplete because it fails to address the QA program's applicability to facility operation, permanent closure, or decontamination and dismantling of surface facilities. As a result, SAR Subsection 5.1.2 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(20) and 63.142(a), and as a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-05 - EMERGENCY PLAN

1. A statement of the contention itself

Legal issue: SAR Subsection 5.7 (and subsections therein), which states that an emergency plan will be provided to the NRC no later than 6 months prior to the submittal of the updated application for a license to receive and possess spent nuclear fuel and high-level radioactive waste, contains a mere commitment to develop an emergency plan as opposed to the plan itself or even a description of the plan.

2. A brief summary of the basis for the contention

Despite the statement that SAR Subsection 5.7 is as complete as possible in light of information that is reasonably available, DOE has not submitted an emergency plan or even a description of an emergency plan but instead, throughout SAR Subsection 5.7, provides mere commitments to provide various elements of an emergency plan and thus:

(i) coordination efforts between emergency response plans of state and local authorities for actions outside the GROA are missing from SAR Subsection 5.7.1.1;

(ii) maps identifying primary routes for emergency response equipment access or evacuation are missing from SAR Subsection 5.7.2.2.4;

(iii) letters of agreement and memoranda of understanding with local emergency response and support organizations to provide firefighting, ambulance, and emergency medical services are missing from Subsection 5.7.2.2.4;

(iv) the protective actions to be taken to protect the health and safety of the public are missing from SAR Subsection 5.7.5.1;

(v) the off-site location of the emergency operations facility and the joint information center is missing from SAR Subsection 5.7.8.1;

(vi) the required quarterly communication and equipment checks and drills with offsite response organizations are missing from SAR Subsection 5.7.12.1; and

(vii) copies of letters of agreement and memoranda of understanding to allow participation by government agencies in emergency response and planning activities are missing from SAR Subsection 5.7.15.2.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the applicable NRC requirements application to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the emergency plan complies with the requirements of 10 C.F.R. Part 63, Subpart I. 10 C.F.R. § 63.21(c)(21) requires a description of the plan for responding to, and recovering from, radiological emergencies that may occur at any time before permanent closure and decontamination and dismantling of surface facilities. 10 C.F.R. § 63.161 (part of Subpart I) restates the requirements of 10 C.F.R. § 63.21(c)(21), and adds that the plan must be based on the criteria of 10 C.F.R. § 72.32(b). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 5.7 states that the information contained within the section is as complete as possible in light of information that is reasonably available, and that an emergency plan compliant with 10 C.F.R. § 72.32(b) will be provided to the NRC no later than 6 months prior to the submittal of the updated application for a license to receive and possess spent nuclear fuel and high-level radioactive waste.

SAR Subsection 5.7.1.1 states that the emergency plan will include coordination with other emergency plans and related actions for activities outside the GROA. SAR Subsection 5.7.2.2.4 states that the emergency plan will include a general map that identifies primary routes for emergency response equipment access or evacuation. SAR Subsection 5.7.2.2.4 also states that the emergency plan will identify the locations of hospitals, fire and police stations, and locations of other offsite emergency support organizations with which a memorandum of understanding has been executed and training offered. SAR Subsection 5.7.5.1 states that the emergency plan will include a description of the protective actions to be taken to protect the health and safety of the public. SAR Subsection 5.7.8.1 states that the emergency plan will identify the off-site location of the emergency operations facility and the joint information center. SAR Subsection 5.7.12.1 states that the emergency plan will include a description of the required quarterly communication and equipment checks and drills with offsite response organizations. SAR Subsection 5.7.15.2 states that copies of letters of agreement and memoranda of understanding (to allow participation by government agencies in emergency response and planning activities) will be included in the emergency plan.

Since each of the above-referenced SAR subsections only includes a commitment to provide information for the emergency plan and does not include the required aspects of an emergency plan or even a description of those aspects, and since such information is reasonably available now, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(21) and 63.161, and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.7 (and subsections therein), which states that the information contained within the section is as complete as possible in light of information that is reasonably available, and that an emergency plan compliant with 10 C.F.R. § 72.32(b) will be provided to the NRC no later than 6 months prior to the submittal of the updated application for a license to receive and possess spent nuclear fuel and high-level radioactive waste. SAR Subsections 5.7.1.1, 5.7.2.2.4, 5.7.5.1, 5.7.8.1, 5.7.12.1 and 5.7.15.2 each contain a commitment to provide information for the emergency plan even though the subject information is reasonably available now. As indicated above, there is sufficient information to believe that the referenced SAR subsections are materially incomplete because they each fail to provide the emergency plan or even a description of the emergency plan, providing instead only a commitment to develop an emergency plan. As a result, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(21) and 63.161, and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-06 - PART 21 COMPLIANCE

1. A statement of the contention itself

Legal issue: SAR Subsections 1.5.1 and 5, which state that DOE will identify and evaluate deviations and failures to comply and will report defects and failures to comply associated with activities for and basic components supplied to the Yucca Mountain repository, fails to address the elements of the program to govern such activities or the procedures for implementing such activities, and therefore there is no assurance that such activities are currently in place or functioning.

2. A brief summary of the basis for the contention

DOE's mere statement that it will comply with the requirements of 10 C.F.R. Part 21 or 10 C.F.R. § 63.73 does not suffice when the operative regulations require a program and procedures to be in place and functioning once DOE's License Application is accepted for docketing.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3)(vi) requires adequate procedures to be in place to protect health and to minimize danger to life or property. In

addition, 10 C.F.R. § 63.73 require DOE to promptly notify the NRC of certain deficiencies found in the characteristics of the Yucca Mountain site, and design, and construction of the GROA based upon a program for evaluating and reporting deviations and failures to comply. Furthermore, 10 C.F.R. §§ 21.1 and 21.2(a)(2) require DOE to have in place a program to ensure that individuals, corporations, partnerships, or other entities doing business with DOE properly identify, evaluate or report failures to comply or defects associated with activities for or basic components supplied to DOE for the Yucca Mountain repository. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Section 5 at 5-2 states that DOE will "comply with 10 C.F.R. Part 21," and that "deficiencies will be identified, evaluated and reported in accordance with approved repository procedures." DOE specifically commits to comply with the requirements of 10 C.F.R. §§ 21.21, 21.41, and 21.51 (*see* SAR Tables 5.2-1, 5.2-2, and 5.2-5). Finally, DOE states in SAR Subsection 1.5.1 at 1.5.1-6 that "Environmental Management implements the applicable requirements of 10 C.F.R. Part 21 for components it, or its principal contractors, provide to be used or accepted at the repository."

With the exception of these simple references and statements, DOE provides no additional information within the License Application with regard to the requirement to comply with 10 C.F.R. Part 21. In addition, DOE does not reference or address in any manner any of the "repository procedures" that allegedly are in place to govern its compliance (or that of its contractors) with Part 21. Accordingly, contrary to the requirements of 10 C.F.R. §§ 21.1 and 21.2(a)(2), DOE does not have in place a functioning Part 21 program to ensure that individuals, corporations, partnerships, or other entities doing business with DOE properly identify, evaluate or report failures to comply or defects associated with activities for or basic components supplied to DOE for the Yucca Mountain repository.

The following general discussion with regard to evaluating deviations, defects, and failures to comply, and reporting the same – i.e., the operative requirement contained within 10 C.F.R. § 21.21 – is found in SAR Subsection 5.2.2 at 5.2-5 (emphasis added):

> As required by 10 CFR 63.73(b), methods ***will be in place*** to evaluate and report deviations and failures to comply, as well as to identify defects and failures to comply, that are associated with substantial safety hazards at the GROA.

By the fact that DOE states that these methods "will be in place," it is clear that DOE has not yet placed such methods in place. Accordingly, DOE has not yet complied with the requirements of 10 C.F.R. § 63.73(b), which requires DOE to "implement a program" for making such evaluations and reports.

Finally, NRC Staff has recently made clear that it will inspect DOE’s compliance with 10 C.F.R. Part 21 after DOE’s License Application is accepted for docketing and during that period of time that the License Application is undergoing NRC Staff review. *See* "Inspection Procedure 78010, 10 CFR Part 21 Program" (NRC Inspection Manual, 9/11/2008); and "Manual Chapter 2300, Yucca Mountain Inspection Program: License Application Review Period" (NRC Inspection Manual, 9/11/2008). Inspections will be conducted to ensure, "If and when the license application (LA) is docketed, DOE will also be subject to the regulations regarding 10 CFR Part 21," which "provides guidance for conducting inspections" pursuant to IP 78010 "to determine if DOE and its suppliers have established a program and procedures to effectively implement 10 CFR Part 21 . . . ." NRC MC 2300, at Section 6.03. Since NRC has accepted for docketing DOE’s License Application, clearly NRC anticipates that DOE will have in place a functioning and effective program and procedures to comply with Part 21.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the statements in SAR Subsections 1.5.1 and 5, that DOE will identify and evaluate deviations and failures to comply and will report defects and failures to comply associated with activities for and basic components supplied to the Yucca Mountain repository, because there is neither a program to govern nor any procedures in place to implement such activities. As a result, SAR Subsections 1.5.1 and 5 are both materially incomplete and inaccurate because specific details are missing and therefore the conclusion reached is unsubstantiated. Therefore, SAR Subsection 1.5.1 and 5 do not comply with the requirements of 10 C.F.R. Part 21 and 10 C.F.R. § 63.73(b), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-07 - RETRIEVAL PLANS AND QA

1. A statement of the contention itself

DOE's description of its plans for retrieval and its QA program are deficient because structures, systems and components necessary for retrieval to be accomplished are not all subject to QA.

2. A brief summary of the basis for the contention

The application of DOE's QA program depends on a structure, system or component being classified as ITWI (important to waste isolation) or ITS (or important to safety). The SAR glossary at xlvi defines some structures, systems and component that are necessary for retrieval as ITS, but the glossary at xlvi does not clearly define any structure, system or component that is necessary for retrieval as ITWI. This means that the QA status of a structure, system or component that is necessary for retrieval depends only on whether it is needed to provide reasonable assurance retrieval will not lead to excessive doses in normal operation and in category 1 and 2 event sequences, ignoring post-closure waste isolation. DOE should have defined all structures, systems and components which are necessary for retrieval as ITWI.

3. A demonstration that the contention is within the scope of the hearing

This contention challenges compliance with 10 C.F.R. Part 63, Subpart G, especially 10 C.F.R. § 63.141(a), and is within the scope of the hearing as provided in section II, paragraph 1 of the notice of hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

In order to issue the construction authorization, 10 C.F.R. § 63.31(a)(3)(iii) requires a finding that DOE's quality assurance program complies with Subpart G, and this contention challenges compliance with Subpart G, especially 10 C.F.R. 63.141(a).

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The application of DOE's QA program depends on a structure, system or component being classified as ITWI or ITS. The SAR glossary at xlvi defines some structures, systems and components that are necessary for retrieval as ITS, but the glossary at xlvi does not clearly define any structure, system or component that is necessary for retrieval as ITWI. This means that the QA status of a structure, system or component that is necessary for retrieval depends only on whether it is needed to provide reasonable assurance retrieval will not lead to excessive doses in normal operation and category 1 and 2 event sequences, ignoring post-closure waste isolation. *See also* SAR Subsection 1.3.6.5 at 1.3.6-8. The SAR says in subsection 1.11.1.1 at 1.11-3 that retrieval will use the same equipment as emplacement, but emplacement equipment can, at most, be categorized ITS. This leads to important structures, systems and components that are necessary for retrieval being omitted from the QA program. For example, while SAR subsection 1.3.4 at 1.3.4-1 and 1.3.4-8 says that the TEV is ITS, the ground support system is not, even though both would be needed in order for retrieval to be accomplished. DOE should have called all structures, systems and components that are necessary for retrieval as ITWI, since section 122 of the NWPA and 10 C.F.R. § 63.21(c)(7) require the ability to retrieve spent fuel, and this ability to retrieve must be considered an essential aspect of providing assurance that the ability of the repository to achieve waste isolation will not be compromised.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges whether the cited provisions of the SAR (glossary at xlvi, subsection 1.3.6.5 at 1.3.6-8, subsection 1.11.1.1 at 1.11-3, subsection 1.3.4. at 1.3.4-1 and 1.3.4-8) and related subsections comply with the Commission regulations. Supporting reasons are that the application of DOE's QA program depends on structures, systems and components being classified as ITWI or ITS, but none of the structures, systems and components that are necessary for retrieval are classified as ITWI. This means that the QA status of a structure, system and component which is necessary for retrieval depends only on whether it is ITS, or needed to provide reasonable assurance retrieval will not lead to excessive doses in normal operation and category 1 and 2 event sequences, a criterion that ignores waste isolation. DOE should have defined all structures, systems and components that are necessary for retrieval as ITWI, as the ability to retrieve must be considered an essential aspect of providing assurance that the ability of the repository to achieve waste isolation will not be compromised.

NEV-SAFETY-08 - ALARA AND THE AGING FACILITY

1. A statement of the contention itself

The discussion of the Aging Facility in SAR Subsection 1.2.7, and related subsections, is insufficient to establish compliance with NRC requirements that occupational exposure to radiation be "as low as reasonably achievable" (ALARA).

2. A brief summary of the basis of the contention

Because specific aging overpack shielding design and Aging Facility layout and loading plans are not provided in the SAR, simplifying assumptions are made in the physical modeling of radiation sources and worker exposure, precluding any credible demonstration that ALARA requirements have been met.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(2) requires information on general arrangement and approximate dimensions of structures at the GROA. 10 C.F.R. § 63.21(c)(6) requires a program for control and monitoring of occupational radiological exposures in accordance with the

requirements of 10 C.F.R. § 63.111. 10 C.F.R. § 63.111(a)(1) requires that the geologic repository operations area to meet the requirements of 10 C.F.R. Part 20. 10 C.F.R. § 20.1101(b) requires DOE to use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as reasonably achievable (ALARA). 10 C.F.R. § 63.111(c) requires the performance of a pre-closure safety analysis that meets the requirements of Section 63.112. 10 C.F.R. § 63.112(e)(2) requires the pre-closure safety analysis to include means to limit the time required to perform work in the vicinity of radioactive materials, and Section 63.112(e)(5) the analysis to include means to control access to high radiation areas or airborne radioactivity areas. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The Aging Facility is designated Radiation Zone R4, with contact dose rates in the range of 15 to 100 mrem/hr with "infrequent occupancy." SAR Table 1.10-1 at 1.10-49 and Figure 1.10-16 at 1.10-121. Further information on classification of radiation zones is provided in DOE reference "Project Design Criteria Document" (10/2007), LSN# DN2002491974. DN2002491974, Table 4.10-3 at 192 states that access in R4 areas is infrequent, and occupancy is expected to be less than 35 hours per year per worker. In addition, "Access to zones R4 and R5 (dose rate greater than 100 mrem/hr) normally requires an ALARA evaluation and approval from higher levels of management." *Id.* DN2002491974 at 189 also identifies the Project Design Criteria (PDC) design goal for the Aging Facility to be 500 mrem/yr.

Notwithstanding the foregoing, the "Hazard Analysis Report: Aging Facility" (04/2008), LSN# DEN001591110 at 45 states that with regard to the Aging Facility, "Routine placement and retrieval operations and routine inspection operations will require occupancy exceeding the defined time and can result in personnel radiation dose exceeding the PDC design goal." DEN001591110 at 51 concludes that these operations are not in keeping with ALARA pursuant to 10 C.F.R. Part 20.

SAR Subsection 1.2.7.1.1 at 1.2.7-4 states that one function of the Aging Facility is that it "protects the workers and the public from radiation." SAR Subsection 1.2.7.6.3 at 1.2.7-12 states, "The aging overpacks are designed to limit the dose rates to less than 40 mrem/hr on contact." "At the aging pad, shielding and loading plans are utilized to reduce the amount of radiation exposure to the workers by reducing the amount of time that they are in proximity to multiple aging overpacks on the same pad." SAR Subsection 1.2.7.2.1 at 1.2.7-9. However, the shielding of the aging overpack has yet to be designed, *see* SAR Subsection 1.10.2.11.1 at 1.10-20, and the ability to accurately project exposures to radiation workers is uncertain because worker tasks are not sufficiently detailed to accurately analyze the dose consequences of operating the Aging Facility. "Because of uncertainties in the final configuration of facilities and equipment, simplifying assumptions are made in the physical modeling of radiation sources and worker exposure pathways. These assumptions will be revised to more realistically reflect expected source terms, shielding design, and layout." *Id*. The existing lack of specific design information and configuration uncertainties precludes any credible demonstration that ALARA requirements have been met with regard to the Aging Facility.

Also with regard to the Aging Facility, the License Application does not conform to two of the ALARA design principles stated in SAR Subsection 1.10.2 at 1.10-5: (a) "Design of SSCs to reduce radiation and contamination levels to ensure that operations and maintenance, including inspection activities, can be performed in lower radiation environments," and (b)

"Design of SSCs to reduce the time spent in radiation environments during operations and maintenance."

From the foregoing, it is apparent that the exposure rate for the Aging Facility is inconsistent with the need for routine worker occupancy on a daily basis during the decades-long repository operations period, and thus is not ALARA. In addition, the SAR does not include a specific plan for limitation of worker occupancy time. Furthermore, the security fence surrounding the Aging Facility, *see* SAR Figure 1.10-16 at 1.10-121, does not fully limit access to non-involved workers and visiting public who could receive exposures of up to 2.5 mrem/hr in unfenced areas outside the Aging Facility.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the SAR's compliance with the requirements of 10 C.F.R. §§ 20.1101(b), 63.21(c)(6) and 63.111(a)(1), that occupational exposure to radiation associated with the Aging Facility be "as low as reasonably achievable" (ALARA), and 10 C.F.R. §§ 63.112(e)(2) and 63.112(e)(5), that the pre-closure safety analysis include means to limit the time required to perform work in the vicinity of radioactive materials and control access to high radiation areas or airborne radioactivity areas.

(2) Post-Closure Safety (including TSPA)

(a) Future Overall Patterns of Climate

NEV-SAFETY-09 - INCREASING CO_2 LEVELS ON FUTURE CLIMATE PROJECTIONS

1. A statement of the contention itself

SAR Subsections 2.3.1.2.1.2, 5.1.6.5, and similar subsections, which state that the infiltration model used for Yucca Mountain applies current meteorological data for the generation of meteorological conditions for predicted future climates in the Yucca Mountain region over the next 10,000 years, fail to acknowledge that atmospheric CO_2 concentrations are increasing at a rate of 1 to 2 ppmv per year, and as a result, the climate states adopted by DOE for the next 10,000 years cannot be justified.

2. A brief summary of the basis for the contention

It is well known to the paleoclimate research community that one of the key forcing functions (that changes through time) for predicting future climate is the concentration of atmospheric CO_2 (and other greenhouse gases), which is currently at approximately 385 ppmv and increasing at a rate of 1 to 2 ppmv per year, and as a result, the climate states adopted by DOE for the next 10,000 years cannot be justified.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. §§ 63.21(c)(11) and (c)(12) require DOE to assess the ability of the Yucca Mountain repository to limit radiological exposures and to limit release of radionuclides as required by 10 C.F.R. §§ 63.113(b) and (c). 10 C.F.R. §§ 63.113(b) and (c) (part of Subpart E of Part 63) require DOE to complete a post-closure performance assessment for the Yucca Mountain repository that meets the requirements of 10 C.F.R. §§ 63.303 and 63.305. 10 C.F.R. § 63.303 (part of Subpart L of Part 63) requires DOE to demonstrate that there is a reasonable expectation of compliance with the requirements in Subpart L of Part 63 before a license can be issued. 10 C.F.R. § 63.305(c) (also part of Subpart L) requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.1.6.5 at 5-26 states that meteorological data at Yucca Mountain has been collected since 1985. A numerical analysis was conducted to identify, extract and reformat those data for use as inputs to an infiltration model within the Yucca Mountain region. The analysis used current meteorological data (*e.g.*, temperature and precipitation) for the generation of meteorological conditions for predicted future climates in the Yucca Mountain region over the next 10,000 years. SAR Subsection 2.3.1.2.1.2 provides more detail on how future climates are predicted.

A primary basis document for the discussion in SAR Subsections 2.3.1, 5.1.6.5 and similar subsections regarding future climates is Forester, *et al.* (8/19/1998), "The Climate and Hydrologic History of Southern Nevada During the Late Quaternary," LSN# DEN001358010. Forester, *et al.*, state (at 7-8) as their central hypothesis that future insolation-correlated climate patterns may resemble those of past periods with similar insolation. However, Forester, *et al.,* do not address the consideration that both insolation and greenhouse gas concentrations are fundamental forcing factors of climate change. *See* "Development and Application of a Methodology for taking Climate-driven Environmental Change into account in Performance Assessments" (BIOCLIM, 2004, Deliverable D10-12) (Châtenay-Malabry, France); and "Climate Change 2007: The Physical Science Basis/Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (IPCC, 2007) (Solomon, S., *et al.* (eds.) Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473). Thus, the central hypothesis in Forester, *et al.*, is flawed and untenable. Because the work of Forester, *et al.*, is used to define the three climate states adopted by DOE for the period up to 10,000 years post-closure, the failure to consider greenhouse gas forcing means that an analysis constrained by those three climate states cannot be supported.

Also, in an internal USGS memorandum from Ike Winograd to Celso Puente dated February 8, 1999, Winograd writes, "I could not help but note on the Manuscript Routing Sheet that this manuscript has received no technical review outside the YMP" (DEN001358010 at 82 of 107). Puente responds by memorandum to Robert Brady dated March 20, 1998, and states, "Another major concern with this report is that the manuscript has received no technical review from outside the Yucca Mountain Project. This is contrary to U.S. Geological Survey reports policy that requires at least two colleague reviews – one internal and one external of the office from which the report originated – by competent reviewers with the appropriate background and expertise" (DEN001358010 at 80-81 of 107). Finally, on September 28, 1998, Forester himself responds with, "I agree with Ike that getting reviews outside of the Yucca Mountain Branch, especially for the countless milestones we produce would be beneficial, but then we would rarely meet the M&O/DOE production schedules" (DEN001358010 at 98 of 107). These remarks clearly demonstrate that Forester, *et al.*, has received inadequate peer review and this may help to explain why it takes such a limited and inadequate view of factors that will affect future changes in climate.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 5.1.6.5 and similar subsections, which state that the infiltration model used for Yucca Mountain applies current meteorological data for the generation of meteorological conditions for predicted future climates in the Yucca Mountain region over the next 10,000 years, because they fail to acknowledge that atmospheric CO_2 concentrations are increasing at a rate of 1 to 2 ppmv per year, and as a result, the climate states adopted by DOE for the next 10,000 years cannot be justified. On this basis, SAR Subsection 5.1.6.5 does not comply with the requirements of 10 C.F.R. § 63.305(c), which requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-10 - CONSIDERATION OF FORCING FUNCTIONS ON FUTURE CLIMATE PROJECTIONS

1. A statement of the contention itself

SAR Subsections 5.2.5.3 (and subsections therein) and 5.2.5.4 and similar subsections, ignore basic aspects of climate forcing relevant to the prediction of climate change over the next 10,000 years, and thus conclusions regarding long-term climate projections are inaccurate and incomplete.

2. A brief summary of the basis for the contention

Although DOE has used orbital precession and eccentricity, paleoclimatic indicators from Devils Hole and Owens Lake, and readings from present-day meteorological analogue stations to predict future climate changes, DOE has failed to consider changes in variance, climate change on time scales that are sub-orbital and longer than inter-annual, and atmospheric circulation alterations caused by loss of ice sheets and rises in sea level, as well as increasing greenhouse gases, in developing long-term climate projections, and as a result, the climate states adopted by DOE for the next 10,000 years cannot be justified.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. §§ 63.21(c)(11) and (c)(12) require DOE to assess the ability of the Yucca Mountain repository to limit radiological exposures and to limit release of radionuclides as required by 10 C.F.R. §§ 63.113(b) and (c). 10 C.F.R. §§ 63.113(b) and (c) (part of Subpart E of Part 63) require DOE to complete a post-closure performance assessment for the Yucca Mountain repository that meets the requirements of 10 C.F.R. §§ 63.303 and 63.305. 10 C.F.R. § 63.303 (part of Subpart L of Part 63) requires DOE to demonstrate that there is a reasonable expectation of compliance with the requirements in Subpart L of Part 63 before a license can be issued. 10 C.F.R. § 63.305(c) (also part of Subpart L) requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The methodology DOE uses to assess how climate could change in the next 10,000 years assumes that future climate can be constrained using orbital-scale climate forcing, along with modern-day analog meteorological stations whose variance is assumed to be invariant in time. This methodology is flawed in that it ignores basic aspects of climate forcing and change relevant to the prediction of climate change over the next 10,000 years. *See, generally*, (1) "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (IPCC, 2007) (Solomon, S., *et al.* (eds.), Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473), (2) "Scientific Assessment of the Effects of Global Change on the United States: A Report of the Committee on Environment and Natural Resources of the National Science and Technology Council" (05/2008) (U.S. Climate Changes Science Program, Suite 250, 1717 Pennsylvania Avenue, N.W., Washington, D.C. 20006), and (3) "Climate Change Science: An Analysis of Some Key Questions" (2001) (U.S. National Research Council, Committee on the Science of Climate Change, National Academy Press, 2101 Constitution Avenue, N.W., Lockbox 285, Washington, D.C. 20055).

First, human activities are resulting in massive emissions of greenhouse gases (*e.g.*, carbon dioxide) to the atmosphere (i.e., an increase of over 35 percent since pre-industrial times, and growing faster in the 21st century than in the late 20th century). At present there is no U.S. federal program being implemented that will eliminate, or even reduce, these anthropogenic levels of greenhouse gases to the atmosphere. Thus, these greenhouse gases will likely result in future climates, centuries to possibly millennia into the future, that are substantially different from those of the past and that are assumed plausible by DOE.

Second, increasing atmospheric greenhouse gas concentrations, unless abated, could result in major changes in ice sheets and ocean circulation, that could, in turn, create future climates even more distinct from past climates, and those assumed for the future by DOE. DOE climate predictions fail to include these possible changes in assessing the range of future climate that could occur in the future, and thus likely underestimate the range of possible future climate change that could occur in the future.

Third, DOE fails to include possible decadal- to millennial-scale variability in their predictions of future climate, even though this scale of variability is known to have been substantial in the past, and could thus be so in the future.

Fourth, DOE fails to include possible abrupt climate in their predictions of future climate, even though significant abrupt climate change has occurred in the past, and could thus occur in the future. *See* "Abrupt Climate Change: Inevitable Surprises" (2002) (National Research Council, National Academy Press, 2101 Constitution Avenue, N.W., Lockbox 285, Washington, D.C. 20055).

All of the above-mentioned omissions mean that future climates at Yucca Mountain could be different from those assumed by DOE. In particular, those climates could be without modern analog. Thus, the use of present-day meteorological station data as analogs for future climate is flawed.

As present-day climate stations are not an adequate analog for future climatic conditions at Yucca Mountain, infiltration, which is determined by climate, will be different from that which DOE has assumed. In turn, this implies that DOE has used unsubstantiated estimates of the amount and chemical composition of seepage waters in the drifts with effects on corrosion, radionuclide transport, and radiological impact on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges that SAR Subsections 5.2.5.3 (and subsections therein) and 5.2.5.4 and similar subsections, which ignore basic aspects of climate forcing relevant to the prediction of climate change over the next 10,000 years, and thus conclusions regarding long-term climate projections are inaccurate and incomplete. Thus, these subsections do not comply with 10 C.F.R. § 63.305(c), which requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-11 - HUMAN-INDUCED CLIMATE CHANGES ON PREDICTION OF THE NEXT GLACIAL PERIOD

1. A statement of the contention itself

SAR Subsection 5.2.5.4 and similar subsections, which state that a cooling trend will be initiated within the first 10,000 years leading to a period of full glacial conditions at about 30,000 years after present, fail to accurately calculate the characteristics of the trend in climate or the timing of the next glacial period because recent studies suggest that, due to human-induced climate changes, it is possible that the Earth will not enter another glacial period for at least 200,000 to 500,000 years, and thus precipitation in excess of that predicted could occur at Yucca Mountain.

2. A brief summary of the basis for the contention

Given the expectation that, due human-induced effects, greenhouse gas concentrations in the atmosphere will continue to increase, the scientific community agrees that the likely human perturbation to the Earth's climate will likely be large and long-lived – possibly lasting hundreds of thousands of years into the future. This means that cooling to glacial conditions could be deferred by 100,000 years or more into the future.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. §§ 63.21(c)(11) and (c)(12) require DOE to assess the ability of the Yucca Mountain repository to limit radiological exposures and to limit release of radionuclides as required by 10 C.F.R. §§ 63.113(b) and (c). 10 C.F.R. §§ 63.113(b) and (c) (part of Subpart E of Part 63) require DOE to complete a post-closure performance assessment for the Yucca Mountain repository that meets the requirements of 10 C.F.R. §§ 63.303 and 63.305. 10 C.F.R. § 63.303 (part of Subpart L of Part 63) requires DOE to demonstrate that there is a reasonable expectation of compliance with the requirements in Subpart L of Part 63 before a license can be issued. 10 C.F.R. § 63.305(c) (also part of Subpart L) requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Given the expectation that concentrations of greenhouse gases in the atmosphere will continue to increase, the scientific community agrees that the likely human perturbation to the Earth's climate will likely be large and long-lived – perhaps lasting hundreds of thousands of years into the future if significant actions are not taken to limit emissions of carbon dioxide to the atmosphere.

- Archer, D. (2005), "The fate of fossil fuel CO_2 in geologic time," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 110, C09505, estimates that the mean lifetime of a 5000 Gton CO_2 release would be long, with a significant portion (ca. 6%)

persisting after 100,000 years. This view is updated and strengthened in Archer, D., and Brovkin, V. (2008), "The millennial atmospheric lifetime of anthropogenic CO_2," CLIMATIC CHANGE Vol. 90, No. 3, 283-297, which highlights that the likely very long residence time of CO_2 means the ocean and ice sheets will be impacted, hence changing global climate in even more complex ways than are likely just in the next few centuries.

- Montenegro, A., Brovkin, V., Eby, M., Archer, D., and Weaver, A.J. (2007), "Long term fate of anthropogenic carbon," GEOPHYSICAL RESEARCH LETTERS, Vol. 34, L19707, 10.1029/2007GL030905, estimates that 25% of a release would persist in the atmosphere much longer than 5000 years, and result in global temperature increases above present of 6-8°C 6800 years into the future.
- Tyrrell, T., Shepherd, J.G., and Castle, S. (2007), "The long-term legacy of fossil fuels," TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY, Vol. 59, No. 4, 664-672, discusses recent model results suggesting that significant impacts will persist for hundreds of thousands of years after emissions cease.
- Archer, D., and Ganopolski, A. (2005), "A movable trigger: fossil fuel CO_2 and the onset of the next glaciation," GEOCHEM., GEOPHYS., GEOSYSTEMS 6, Q05003, estimate that a release of 5000 Gton C to the atmosphere from fossil fuel burning and/or methane clathrate release would likely preclude the Earth from entering another full glacial state for up to 500,000 years. And even if CO_2 emissions are greatly reduced in the future and that human emissions only lead to a doubling of pre-industrial CO_2 levels, then it is still possible that the earth would not enter another full glacial state for 200,000 years.

Thus, contrary to SAR Subsection 5.2.5.4 and similar subsections, which state that a cooling trend will be initiated within the first 10,000 years leading to a period of full glacial conditions at about 30,000 years after present, the scientific expectation is of a warming trend initiated within the next 10,000 years and resulting in a suppression of glacial conditions for 200,000 years or more. This difference in the trend in climate characteristics over time has the potential to affect the characteristics of precipitation at Yucca Mountain both within the next 10,000 years and thereafter, with implications for infiltration, EBS performance and radionuclide transport.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.2.5.4 and similar subsections, which state that a cooling trend will be initiated within the first 10,000 years leading to a period of full glacial conditions at about 30,000 years after present, because recent studies suggest that, due to human-induced climate changes, the scientific expectation is of a warming trend initiated within the next 10,000 years and resulting in a suppression of glacial conditions for 200,000 years or more. Therefore, SAR Subsection 5.2.5.4 and similar subsections fail to satisfy the requirements of 10 C.F.R. § 63.305(c) which requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-12 - PROJECTIONS OF FUTURE WETTER CLIMATE CONDITIONS

1. A statement of the contention itself

SAR Subsection 2.3.1.2.3.1.2 at 2.3.1-27 through 2.3.1-31, and similar subsections, which define the Analogue Meteorological Stations used for the Yucca Mountain climate forecast for the next 10,000 years, fail to account for the significantly greater summer monsoon rainfall amounts that could occur as a result of continued global warming.

2. A brief summary of the basis for the contention

Climate modeling indicates that continued global warming could lead to greater summer monsoon rainfall at Yucca Mountain over the next 10,000 or more years than is associated with the monsoon meteorological analog sites in New Mexico and Arizona.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. §§ 63.21(c)(11) and (c)(12) require DOE to assess the ability of the Yucca Mountain repository to limit radiological exposures and to limit release of radionuclides as required by 10 C.F.R. §§ 63.113(b) and (c). 10 C.F.R. §§ 63.113(b) and (c)

(part of Subpart E of Part 63) requires DOE to complete a post-closure performance assessment for the Yucca Mountain repository that meets the requirements of 10 C.F.R. §§ 63.303 and 63.305. 10 C.F.R. § 63.303 (part of Subpart L of Part 63) requires DOE to demonstrate that there is a reasonable expectation of compliance with the requirements in Subpart L of Part 63 before a license can be issued. 10 C.F.R. § 63.305(c) (also part of Subpart L) requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years. DOE must also address post-10,000 year impacts consistent with the newly promulgated rule by the U.S. Environmental Protection Agency at 40 C.F.R. Part 197, 73 Fed. Reg. 61256 (10/15/2008). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

More than one of the 22 climate models used by the Intergovernmental Panel on Climate Change Fourth Assessment simulated an increase in summertime (monsoonal) rainfall in the Southwest, including the region encompassing Yucca Mountain. *See* "Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (IPCC, 2007) (Solomon, S., *et al*. (eds.), Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473). In at least one case, the simulated increase was enough to at least double the rainfall amounts estimated by the use of monsoon analogue meteorological stations in SAR Subsection 2.3.1.2.3.1.2 if global greenhouse gas emissions to the atmosphere continue at their recent pace. In addition, summer rainfall would likely occur in a manner more intense than at present, or as estimated for the future by DOE, due both to its convective nature and a warmer future atmosphere. *See* IPCC, 2007; and "Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands, A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research," CCSP (2008) (Karl, T.R., *et al.* (eds.) U.S. Department of Commerce, NOAA's National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville, Nye County 28801-5001).

Available paleoclimate data also support the possibility that the Yucca Mountain region will be wetter than assumed in SAR Subsection 2.3.1.2.3.1.2 as continued global warming increases the temperature of North America. For example, one of the wettest periods in the last 500,000 years appears to have been the last interglacial period (MIS 5 or "Eemian" in normal paleo terminology) about 130,000 to 116,000 years ago. That period was at least as warm as today, and probably at least 2-3°C warmer in the Western U.S., due to more insolation in summer as a result of changes in the Earth's orbit. *See* (1) Montoya, M., von Storch, H., and Crowley, T.J. (2000), "Climate simulation for 125 kyr BP with a coupled ocean-atmosphere general circulation model," JOURNAL OF CLIMATE, Vol. 13, No. 6 at 1057-1072; (2) Otto-Bliesner, B.L., Marshall, S.J., Overpeck, J.T., Miller, G.H., Hu, A., and CAPE-Project-Members (2006), "Simulating arctic climate warmth and icefield retreat in the Last Interglaciation," SCIENCE Vol. 311, No. 5768 at 1751-1753; and (3) Jansen, E., Overpeck, J.T., and 47 others (2007), "Chapter 6: Paleoclimate, in: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (Solomon, S., *et al.* (eds.), Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473), at 433-497. Evidence of wetter monsoonal climate than present at Yucca Mountain includes both diatom assemblages (*see* Forester, *et al.*

(8/19/1998), "YMP-USGS Open File Report 98-635 - The Climatic and Hydrologic History of Southern Nevada During the Late Quaternary" LSN# DEN001358010), as well as more recent geochemical data (*see* Li, H.C., Bischoff, J.L., Ku, T.L., and Zhu, Z.Y. (2004), "Climate and hydrology of the Last Interglaciation (MIS 5) in Owens Basin, California: isotopic and geochemical evidence from core OL-92, 2004," QUATERNARY SCIENCE REVIEWS, Vol. 23, No. 1-2 at 49-63), which indicates that Owens Lake was overflowing during at least part of this period.

Fracture flow and calcite/opal precipitation occurred during the warm/wet conditions of the last interglacial period (DEN001358010). DOE acknowledges that wet interglacial climates have occurred and could occur again in the future. *Id*. at 13, 24; "Future Climate Analysis, ANL-NBS-GS-000008 Rev. 001" (9/3/2004), LSN# DN2001637047. There were also interglacial periods in the Yucca Mountain region that appear to have been warmer and wetter than the "typical" interglacial period. *See* Forester, *et al.* (1998), USGS Open File Report. During these periods, the Subtropical Highs would have expanded and/or intensified, resulting in a northward shift of the southwestern monsoon. Summer precipitation probably increased dramatically.

In summary, both simulations of future climate under continued global warming, as well as paleoclimatic evidence from the Yucca Mountain region, support the possibility that summer monsoonal rainfall could be significantly greater, and more intense, than assumed by DOE. The significance of this possibility is made greater by the likelihood that hot monsoonal climates could also be much more the norm at Yucca Mountain than assumed by DOE as a result of DOE's failure to consider not only that global warming is likely to be a factor but that it could be a factor for many thousands of years to come. *See, e.g.*, Archer, D., and Brovkin, V. (2008), "The millennial atmospheric lifetime of anthropogenic CO_2," CLIMATIC CHANGE, Vol. 90, No. 3 at 283-297.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.1.2.3.1.2, which defines the Analogue Meteorological Stations use for the Yucca Mountain climate forecast for the next 10,000 years, fails to account for the significantly greater summer monsoon rainfall amounts that could occur as a result of continued global warming. Thus, this subsection does not comply with 10 C.F.R. § 63.305(c), which requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(b) Spatial and Temporal Distribution of Precipitation

NEV-SAFETY-13 - FUTURE CLIMATE PROJECTIONS NEED TO INCLUDE EXTREME PRECIPITATION EVENTS

1. A statement of the contention itself

SAR Subsection 2.3.1.2.3.1.2 and similar subsections, which define the climate forecast at Yucca Mountain for the next 10,000 years, fail to accurately account for the more frequent intense rainfall or for the large storm-related rainfall events that could occur as a result of continued global warming.

2. A brief summary of the basis for the contention

Climate theory, observations and models indicate that continued global warming could lead to more frequent intense rainfall events and more large moisture-laden remnant tropical storms at Yucca Mountain over the next 10,000 or more years, all generating larger rainfall amounts at the site than currently estimated.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. §§ 63.21(c)(11) and (c)(12) require DOE to assess the ability

of the Yucca Mountain repository to limit radiological exposures and to limit release of radionuclides as required by 10 C.F.R. §§ 63.113(b) and (c). 10 C.F.R. §§ 63.113(b) and (c) (part of Subpart E of Part 63) require DOE to complete a post-closure performance assessment for the Yucca Mountain repository that meets the requirements of 10 C.F.R. §§ 63.303 and 63.305. 10 C.F.R. § 63.303 (part of Subpart L of Part 63) requires DOE to demonstrate that there is a reasonable expectation of compliance with the requirements in Subpart L of Part 63 before a license can be issued. 10 C.F.R. § 63.305(c) (also part of Subpart L) requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years. DOE must also address post-10,000 year impacts consistent with the newly promulgated rule by the U.S. Environmental Protection Agency at 40 C.F.R. Part 197, 73 Fed. Reg. 61256 (10/15/2008). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

There is growing confidence in the climate science community that the intensity of rainfall will increase as the global warming continues. *See, e.g.*, (1) "Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (2007) (Solomon, S., *et al.* (eds.), Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473); (2) "Scientific Assessment of the Effects of Global Change on the United States: A Report of the Committee on Environment and Natural Resources National Science and Technology Council" (2008) (U.S. Climate Change Science Program, Suite 250 1717 Pennsylvania Avenue, Washington, D.C. 20006); (3) "Weather and Climate Extremes in a Changing Climate, Regions of Focus: North

America, Hawaii, Caribbean, and U.S. Pacific Islands, A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research" (2008) (Karl, T.R., *et al.* (eds.), Department of Commerce, NOAA's National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville, Nye County 28801-5001); and (4) Allan, R.P., and Soden, B.J. (2008), "Atmospheric warming and the amplification of precipitation extremes," SCIENCE, Vol. 321, No. 5895 at 1481-1484. This is a consequence of the increased moisture-holding capacity of a warmer lower atmosphere relative to evaporation. *See* Trenberth, K.E., Dai, A.G., Rasmussen, R.M., and Parsons, D.B. (2003), "The Changing Character of Precipitation," BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY, Vol. 84, Issue 9 at 1205-1217. Because anthropogenic carbon-dioxide emissions could remain in the atmosphere for thousands, tens of thousands, and even hundreds of thousands of years, greater rainfall intensity is possible at Yucca Mountain during and beyond the next 10,000 years.

Continued global warming may also increase the strength and intensity of tropical storms and hurricanes. *See, e.g.*, (1) Climate Change, 2007, *supra*; (2) Scientific Assessment, 2008, *supra*; and (3) Weather and Climate Extremes, 2008, *supra*. This means these storms may be able to rain out more water in the future, even as they move over land and weaken into remnant tropical storms. Also as a result of continued global warming and circulation changes, it is possible that large storm-related rainfall events will be able to reach the Yucca Mountain region with greater frequency than observed in the period of instrumental observation. Rainfall events lasting up to a week (*e.g.*, when a tropical storm collides with a frontal storm) and exceeding 50 cm are possible. Such events could occur several times per year. Already, some areas of the southwest United States experience several intense storms in a year, and climate change has the potential to induce changes in atmospheric circulation that would favor the induction of more such storms, increase the power of individual storms, and increase the likelihood of such storms reaching the area of Yucca Mountain. Because anthropogenic carbon-dioxide emissions could remain in the atmosphere for thousands, tens of thousands, and even hundreds of thousands of years, greater rainfall amounts are possible at Yucca Mountain during and beyond the next 10,000 years.

There is also paleoclimate evidence for multiple wetter – and more flood prone – periods in the Southwestern U.S. than previously assumed for the last 7000 years. *See* Ely, L.L., Enzel, Y., Baker, V.R., and Cayan, D.R. (1993), "A 5000-Year Record of Extreme Floods and Climate-Change in the Southwestern United-States," SCIENCE, Vol. 262, No. 5132 at 410-412. Although the cause of these events has not yet been determined, consideration should be given to such century-to-millennia length wet events occurring again in the future. These paleoclimatic events make it clear that use of average modern-day precipitation conditions, as well as ignoring century-to-millennium scale climate variability, can create misleading results regarding the amount of rainfall that will occur at Yucca Mountain in the future.

DOE has failed to consider how the infiltration responds to large events (*e.g.*, intense rain storms, including the sustained presence of remnant tropical storms, or the type that caused increased Southwest U.S. flooding in the last 7000 years) that could be more common in the future. In addition, DOE's conclusions regarding extreme events (*e.g.*, wet) are based on analog sites and their expanded standard deviations which are flawed for two reasons. First, the climate dynamics of the analog sites are not the same as at Yucca Mountain. For example, Yucca Mountain can theoretically experience flooding due to rain or snow events, exceptional convection with rare moisture-laden frontal storms, and remnant tropical storms perhaps coincidental with exceptional monsoons. However, none of these types of flooding scenarios may be true for the analog sites. Second, the largest extremes are usually, if not always, found in paleo records, and the paleo record for Yucca Mountain is sparse. For example, Devils Hole samples average a sampling interval of ca. 1,500 years, effectively smoothing out any exceptional extremes. The same may be true for Owens Lake.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.1.2.3.1.2, which defines the climate forecast at Yucca Mountain for the next 10,000 years, fails to accurately account for the more frequent intense rainfall, or for the large storm-related rainfall events that could occur as a result of continued global warming. Thus, this subsection does not comply with 10 C.F.R. § 63.305(c), which requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to

each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-14 - PRECIPITATION MODEL

1. A statement of the contention itself

The precipitation component of the net infiltration model, which is described in SAR Subsection 2.3.1.3.2 and similar subsections, is fundamentally flawed because it relies upon modeling that fails to represent physical and empirical aspects of the precipitation process, and because no attempt has been made to investigate important aspects of its performance.

2. A brief summary of the basis for the contention

The precipitation component of the net infiltration model does not adequately incorporate important physical phenomena, uses inappropriate assumptions that are not consistent with the body of data presented in the description, provides results that are not consistent with empirical observations, and does not attempt to evaluate important aspects of performance such as extremes.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(e) requires the performance assessment to provide the technical basis for either inclusion or exclusion of specific features, events and processes, and to evaluate specific features, events and processes in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsections 2.3.1 and 2.4.2.3.2 explain how the MASSIF net infiltration model uses simulated precipitation sequences to derive estimates of net infiltration for use in the unsaturated zone flow component of the TSPA model. SAR Subsection 2.3.1.1 at 2.3.1-4 explains that in the arid climate of Yucca Mountain, "precipitation events are intermittent and result in long periods of time when there is a net evapotranspiration from the surficial soils interspersed with short-duration precipitation events that can result in some infiltration." For the purposes of the LA, therefore, it is important that the precipitation component of the net infiltration model is able to reproduce the characteristics of short-duration precipitation events, and in particular the extreme events that are expected to dominate the occurrence and magnitude of net infiltration. For example, the 1997 Unsaturated Zone Flow Modeling Expert Elicitation Panel, LSN# NRC000010491 at 3-7 and 3-8, concluded that significant infiltration was likely to arise only from episodic events which occurred with frequencies ranging from annual to decadal, and that hourly data resolution was required to define them.

In fact, the precipitation input for net infiltration is modelled on a daily time step, but even at this time-scale no evaluation is made of critically important effects such as persistence and extremes. The only features considered (*see* SAR Subsection 2.3.1.3.4) are the reproduction of the seasonal cycle and the distribution of mean annual precipitation (MAP) and the results from these are unconvincing. For example, different descriptive criteria are used to justify the performance with respect to MAP for each climate state. The results show that at half of the sites considered there are two distinct wet seasons and that the precipitation model is not capable of representing this behaviour. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV 01 ADD 01" (01/28/2008), LSN# DEN001575070, Section 7.1.1.1 at 7-4.

At SAR page 2.3.1-76, DOE argues that the effect of this is unclear because "the average annual precipitation is preserved, and only the monthly distribution is affected." However, this argument is incorrect because the effect is to smooth out the seasonal variation (*see, e.g.*, DEN001575070 at Figure 7.1.1.1-6) and hence to under-represent the occurrence of the types of precipitation events that will result in infiltration.

Another flaw in the precipitation component of the model relates to the elevation relationships used to adjust present-day climate parameters to a reference elevation of 1,524 meters, and to those used to produce spatial precipitation fields by scaling the generated precipitation sequences. *See* DEN001575070, Appendix F2.1at F-14 through F-21. Separate linear relationships are used to adjust four of the precipitation model parameters (as described in Tables F.4 and F.5 of DEN001575070) and the MAP. However, these relationships are mutually inconsistent since, if the expected MAP is calculated from the adjusted precipitation parameters, the result does not vary linearly with elevation. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV01" (05/24/2007), LSN# DN2002482668, Eq. F.41 and F.42 at F-11.

A further example of a flaw in the precipitation model is that it is parameterized in such a way that logical impossibilities such as negative probabilities can arise (*e.g.*, if the parameter $b_{00}>a_{00}$ in SAR Equation 2.3.1-1). This causes complications for uncertainty analyses, where parameter ranges are subject to constraints. *See, e.g.*, DN2002482668 at F-32.

In sum, the precipitation component of the net infiltration model does not adequately incorporate important physical phenomena, uses inappropriate assumptions that are not consistent with the body of data presented in the description and provides results that are not consistent with empirical observations. Furthermore, no attempt has been made to evaluate important aspects of performance such as extremes. Flaws in the model itself include failure to represent seasonality adequately at half of the sites considered and erroneous representation of the rainfall-elevation relationship which is relied upon to generate spatial rainfall for input into the net infiltration model. Both of these are important physical phenomena that may have a substantial impact on net infiltration estimates, whence their omission may significantly change estimates of radiological exposure. Furthermore, the model assumptions are such that it has the potential to produce physically impossible parameter combinations (for example, probabilities outside the range [0,1]).

The effect of the mischaracterization of precipitation will be to induce a downward bias in estimates of net infiltration. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the precipitation component of the net infiltration model as described in SAR Subsection 2.3.1.3.2, which in turn relies on DN2002482668 and DEN001575070, because it fails to adequately incorporate important physical phenomena, uses inappropriate assumptions that are not consistent with the body of data presented in the description, provides results that are not consistent with empirical observations, and no attempt has been made to evaluate important aspects of performance such as extremes. As a result, SAR Subsection 2.3.1.3.2 is both materially incomplete and inaccurate, and therefore does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(9) and (c)(15) and 63.114(e). Therefore, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include

the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-15 - ALTERNATIVE PRECIPITATION MODELS AND WEATHER VARIABLES

1. A statement of the contention itself

The precipitation and weather components of the net infiltration model described in SAR Subsection 2.3.1.3.2 are not sufficient because alternative conceptual models exist that are consistent with the available data and with current scientific understanding, and by neglecting these, DOE has substantially underestimated the uncertainty inherent in the results of the performance assessment.

2. A brief summary of the basis for the contention

Alternative conceptual models of the components of the net infiltration model relating to precipitation and weather variables have not been considered despite the availability of techniques that could provide a much improved representation of these processes.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(c) requires consideration to be given to alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and to evaluate the effects that alternative conceptual models have on the performance of the geologic repository. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>Concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The precipitation component of the net infiltration model is deficient in several important respects. Simplifying assumptions are made for components relating to other weather variables such as temperature. Advanced precipitation models are available that could overcome these deficiencies and avoid use of these assumptions. In order to meet the requirement of 10 C.F.R. § 63.114(c) it is necessary to evaluate the effects that the use of such models could have on the performance of the geological repository. However, this has not been done by DOE.

The precipitation component of the net infiltration model is based on Woolhiser, D.A. and Pegram, G.G.S., "Maximum Likelihood Estimation of Fourier Coefficients to Describe Seasonal Variations of Parameters in Stochastic Daily Precipitation Models," JOURNAL OF APPLIED METEOROLOGY, Vol. 18 AT 34-42, TIC: 257886 (Boston, Massachusetts: American Meteorological Society, 1979). This type of model is known to perform poorly with respect to a number of hydrologically important features. *See, e.g.*, Wilks, D.S. and Wilby, R.L., "The Weather Generation Game: A Review of Stochastic Weather Models," PROGRESS IN PHYSICAL GEOGRAPHY, 23(3):329-357 (1999). Advanced models have been developed over the last 30 years that perform much better with respect to features such as extremes and inter-annual variability, have more flexibility to represent complicated seasonal patterns and also avoid problems such as the potential to produce negative probabilities.

The precipitation component of the net infiltration model also contains an oversimplified treatment of spatial variability. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV01" (05/24/2007), LSN# DN2002482668 at Section 6.4.1.1. Spatial rainfall is generated, at a daily time-step, by multiplying a single-site sequence (for a reference elevation of 1,524 meters) by an elevation surface derived from an analysis of annual precipitation totals. One problem with this approach is that the derived elevation surface is regionally based and will fail to reproduce the local-scale meteorological controls on the spatial distribution of precipitation. Another problem with this approach is that the use of annual relationships masks the variability that can be expected for daily precipitation. It is acknowledged (DN2002482668 at 6-25) that "a more complicated model might allow precipitation to occur in parts of the domain while other parts of the domain remain dry." In reality, the spatial structure is complex on sub-daily time scales, particularly for convective rainfall, and even if uniform spatial coverage were observed at the daily time-step (which is not to be expected), the non-linear hydrological response to sub-daily sequences of spatially localised precipitation would not be represented correctly by this assumption. It is necessary to quantify the effect of this in order to justify the claim that "such sophistication was deemed unnecessary for the current development." (DN2002482668 at 6-25).

Elsewhere in the weather-related components of the net infiltration model, there are several places (such as the representation of temperature and the derivation of rain event durations from daily rainfall totals) where a quantity of interest is treated as a deterministic function of some other quantities, but where the data show considerable scatter about the fitted relationships. Elsewhere it is argued that the derivation of storm durations is flawed and underestimates the intensity of short-duration high-intensity rainfall events. Similarly here, the observed temperature time series show considerable scatter about the assumed deterministic cycles. *See, e.g.*, "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV 01 ADD 01" (01/28/2008), LSN# DEN001575070, Fig. F-2 at F-14. In addition, simplifying assumptions are made for several other weather variables as well – for example, solar radiation is derived from air temperature (DN2002482668 at 6-38) and wind speed is not adjusted for elevation (DN2002482668 at 6-41). Since net infiltration is a nonlinear function of the weather inputs, any failure to account for variability in these inputs would potentially affect the estimates of average infiltration and hence, ultimately, radiological exposure. It is therefore necessary to consider alternative conceptual models that allow for variability in the inputs, and to evaluate the effects that the use of such models would have on the performance of the repository.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

As explained above, the precipitation and weather components of the net infiltration model described in SAR Subsection 2.3.1.3.2 are not sufficient because alternative conceptual models exist that are consistent with the available data and with current scientific understanding, and by neglecting these, DOE has substantially underestimated the uncertainty inherent in the results of the performance assessment. Thus, SAR Subsection 2.3.1.3.2 does not comply with 10

C.F.R. § 63.114(c), which requires consideration to be given to alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and to evaluate the effects that alternative conceptual models have on the performance of the geologic repository.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-16 - QUALIFICATION OF CLIMATE AND INFILTRATION MODELS

1. A statement of the contention itself

SAR Subsection 2.3.1, which describes the analysis and modeling underpinning the climate and infiltration components of the TSPA, fails to provide details of data qualification procedures used in this work and fails to identify any formal peer reviews used in its preparation.

2. A brief summary of the basis for the contention

The SAR does not contain a description of the quality assurance program applied to the acquisition, control and analysis of samples and data.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(20) requires that the SAR to include a description of the quality assurance program to be applied to the structures, systems and components important to safety. 10 C.F.R. § 63.142(a) (part of Subpart E of 10 C.F.R. Part 63) extends the requirement to apply to the components important to safety, to design and characterization of barriers important to waste isolation, and to related activities, which include acquisition, control

and analysis of samples and data. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials.

The cited provisions of 10 C.F.R. Part 63 require the SAR to include a description of the quality assurance program, which covers the control and analysis of samples and data. NUREG-1804, Section 2.2.1.3.5.3, Acceptance Criterion 1(8) sets out explicitly what is required to meet Part 63 in this regard: "Guidance in NUREG–1297 and NUREG–1298 . . . , or other acceptable approaches for peer reviews and data qualification, is followed." The only mention of this in the SAR is the following statement on page 2.3.1-1,

> "scientific analyses, model development, and data qualification activities were conducted in accordance with project procedures that comply with Quality Assurance Program requirements. The project procedures governing data qualification are consistent with NUREG-1298 (Altman, *et al.,* 1988) in keeping with Acceptance Criterion 1(8)."

This statement does not constitute a description of the quality assurance program. In addition, the SAR must therefore include a description of the procedures used for data qualification.

According to page 2.3.1-1 of the SAR, "no formal peer reviews were used to support development of the current models and analyses discussed in Section 2.3.1." This constitutes a failure to apply appropriate quality control procedures to the analysis of data.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

As noted above, this contention challenges the failure of SAR Subsection 2.3.1 to include a description of the quality assurance program as applied to the acquisition, control and analysis of samples and data (as opposed to a mere statement that such activities were conducted in accordance with procedures that comply with a quality assurance program). As a result, SAR Subsection 2.3.1 is materially incomplete, and therefore fails to comply with the requirements of

10 C.F.R. §§ 63.21(c)(20) and 63.142(a). Therefore, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-17 - CALIBRATION AND SIMULATION OF PRECIPITATION MODEL

1. A statement of the contention itself

The procedures used to calibrate and simulate the precipitation component of the precipitation model, as referenced in SAR Subsection 2.3.1.3.2, are non-standard, not generally accepted and, in the case of the simulation procedure as described, incorrect.

2. A brief summary of the basis for the contention

The precipitation component of the net infiltration model is calibrated using a non-standard least squares procedure that is not generally accepted; the simulation methodology as described adopts the dubious procedure of using the same pseudo-random number to generate both rainfall occurrence and amounts of rainfall; and the procedure used for sampling from a lognormal distribution is not generally accepted.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph

(c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The procedure for calibrating the precipitation component of the net infiltration model was developed for the first time in "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV01" (05/24/2007), LSN# DN2002482668 , where it is described in Appendix F1.1.2. This procedure is flawed because more widely accepted superior procedures are available and in common use. The algorithm for simulating precipitation sequences, as described at F.36 of DN2002482668, is also incorrect and does not use generally accepted techniques for drawing from a lognormal distribution.

As acknowledged at F.5 of DN2002482668, precipitation models of the type considered here are usually fitted using the method of maximum likelihood. This approach, which is applicable here, has a number of desirable properties which are well understood, including the availability of uncertainty estimates for all parameters. However, DOE did not follow this approach and instead developed its own least squares procedure whose properties were not explored. Moreover, DOE's reason for not using the fitting method and instead using the least squares method is inconsistent. DOE says that "it is desirable to have a procedure that is more transparent than optimization software" (DN2002482668 at F.5), but then uses optimization software to calibrate the temperature model (*id.* at F.12). Furthermore, the calibration procedure is complicated by the amplitude-phase parameterization of the seasonal cycle. The accepted procedure here is to re-parameterize in terms of sine and cosine components, in which case the problem becomes a standard application of regression techniques and their variants.

In terms of the TSPA, the main impact of the fitting methodology is that it provides no objective basis for the assessment of parameter uncertainty. Had DOE used a standard procedure then, in addition to generating best estimates of the parameters, justified estimates of the uncertainties in those parameters would have been generated. However, because a non-standard procedure was used, only best estimates of the parameters were made available and not justified uncertainties on those parameters. The method adopted therefore fails to provide an objective basis for undertaking calculations of infiltration, because it does not deliver the well-justified parameter distributions that are required for a probabilistic assessment of the effects of parameter uncertainty.

In addition to the problems associated with the calibration of the model, DOE's implementation of the model, as described at F.36 of DN2002482668, is incorrect since it uses the same pseudo-random number to determine both the occurrence and amount of rainfall. Moreover, the method utilized by DOE for generating pseudo-random numbers from lognormal distributions (*see* DN2002482668, equations F-50 and F-51) is not generally accepted. The method is also slow and could be relatively inaccurate, especially in the tails of the distribution, since it requires inversion of the lognormal distribution function. Modern methods for simulating from lognormal distributions rely on the relationship between the lognormal and normal distributions, and the availability of efficient and exact methods for sampling from the latter. *See, e.g.,* A.C. Davison, "Statistical Models" (Cambridge University Press 2003) at Section 3.3.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the procedures that were used to calibrate and simulate the precipitation component of the precipitation model, as referenced in SAR Subsection 2.3.1.3.2, because they are non-standard, not generally accepted and, in the case of the simulation procedure as described, incorrect. As a result, SAR Subsection 2.3.1.3.2 does not comply with the requirements of 10 C.F.R. § 63.21(c)(9), which requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) which requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9).

NEV-SAFETY-18 - USE OF CLIMATE DATA FROM THE ANALOG SITES

1. A statement of the contention itself

SAR Subsection 2.3.1.2.3 and similar subsections, which describe the use of analog sites to represent future climate states, make inappropriate use of information from the analog sites.

2. A brief summary of the basis of the contention

To support the modeling of net infiltration for each future climate scenario in the TSPA, information from several analog sites is pooled, but the chosen sites have quite different climatologies so that the result of the pooling cannot be considered to correspond to any single physically plausible climate state and hence the use of the information is inappropriate.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether the DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in

parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. Also, 10 C.F.R. § 63.21(c)(15) requires the SAR to contain an explanation of measures used to support the models used to provide the information required in paragraphs (c)(9) through (c)(14). Furthermore, it requires that analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, *in situ* tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.1.2.3 explains how future climate regimes are represented in the TSPA by fitting temperature and precipitation models to historical data from present-day analog stations. The fitted models are used to generate 1,000-year synthetic weather sequences as input to the net infiltration component of the TSPA. Two analog stations are chosen to represent the upper-bound monsoon climate, three stations for the lower-bound glacial transition climate, and two stations for the upper-bound glacial transition climate. The lower-bound monsoon climate was represented using the present-day stations around Yucca Mountain. For each future climate regime, uncertainty distributions for the model parameters were obtained by pooling results from upper- and lower-bound sites representing that regime.

Although the analog stations are nominally chosen in such a way that DOE regards them as representative of the forecast future regimes at Yucca Mountain, the subsequent results presented in SAR Subsection 2.3.1.2.3 show that there are substantial differences between sites that are supposed to represent the same climate. For example, for the upper-bound monsoon climate, the amplitudes of the seasonal cycles in precipitation model parameters at the two selected stations differ by more than a factor of two in some instances (*see* SAR at 2.3.1-41); the seasonal cycle in precipitation is reversed between the upper- and lower-bound monsoon climates (*id.*); and the seasonal cycles at Spokane and Delta, representing upper- and lower-bound glacial transitions, respectively, are completely different (compare "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV 01 ADD 01" (1/28/2008), LSN# DEN001575070, Figures 7.1.1.1-5[a] and 7.1.1.1-6[a]). A consequence of this approach is that the chosen sites cannot possibly all represent the same climate regime, and the results obtained by pooling results from different sites are not shown to correspond to any physically plausible climate state. DOE makes an attempt to justify the pooling for the monsoon climate – "The climate during this period would vary from episodes of intense summer rain to present-day-like climates with relatively more winter and less summer precipitation." SAR at 2.3.1-41. However, the correct way to represent this in a 1,000-year climate simulation is not by using a fixed parameter set drawn from the pooled results, but rather by allowing the parameters to vary within the simulation so as to reflect the actual process that is expected to occur. The data from the analog sites have therefore been used inappropriately, and therefore the requirement in 10 C.F.R. § 63.21(c)15 – that "[a]nalyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as . . . natural analog studies" – has not been met. Furthermore, the parameter values derived do not comply with the requirement of 10 C.F.R. § 63.114(b), in that the technical basis for the parameter ranges used to describe future climatic conditions is flawed.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted.</u>

SAR Subsection 2.3.1.2.3 and similar subsections, which describe the use of analog sites to represent future climate states, make inappropriate use of information from the analog sites. In consequence, these subsections do not comply with 10 C.F.R. § 63.21(c)(15), which requires that "[a]nalyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as . . . natural analog studies." Furthermore, the parameter values derived do not comply with the requirement of 10 C.F.R. § 63.114(b), in that the technical basis for the parameter ranges used to describe future climatic conditions is flawed.

(c) Infiltration Modeling

NEV-SAFETY-19 - FUTURE INFILTRATION PROJECTIONS NEED TO INCLUDE REDUCED VEGETATION COVER

1. A statement of the contention itself

SAR Subsection 2.3.1.3.2.1.5 and related subsections, which state the nature of vegetation cover predicted for the future at Yucca Mountain, fail to account accurately for the possible impact of reduced vegetation cover that could result in increased rates of infiltration.

2. A brief summary of the basis for the contention

Continued global warming will likely result in hotter and drier winter climates at Yucca Mountain within the next 10,000 years and this climatic change could cause vegetation to become more sparse for extended periods, allowing for greater infiltration when intense rains occur.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain.

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. §§ 63.21(c)(11) and (c)(12) require DOE to assess the ability of the Yucca Mountain repository to limit radiological exposures and to limit release of

radionuclides as required by 10 C.F.R. §§ 63.113(b) and (c). 10 C.F.R. §§ 63.113(b) and (c) (part of Subpart E of Part 63) requires DOE to complete a post-closure performance assessment for the Yucca Mountain repository that meets the requirements of 10 C.F.R. §§ 63.303 and 63.305. 10 C.F.R. § 63.303 (part of Subpart L of Part 63) requires DOE to demonstrate that there is a reasonable expectation of compliance with the requirements in Subpart L of Part 63 before a license can be issued. 10 C.F.R. § 63.305(c) (also part of Subpart L) requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years. DOE must also address post-10,000 year impacts consistent with the newly promulgated rule by the U.S. Environmental Protection Agency at 40 C.F.R. Part 197, 73 Fed. Reg. 61256 (10/15/2008). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In SAR Subsection 2.3.1.3.2.1.5, DOE outlines how vegetation cover at Yucca Mountain is predicted. The methodology used fails to incorporate the likely impacts of anthropogenic climate change that could affect vegetation for the next 10,000 or more years, and thus DOE has failed to incorporate vegetation change that could result in greater infiltration of rain at Yucca Mountain.

There is evidence that infiltration will increase if vegetation cover becomes reduced at the location of the Yucca Mountain repository. *See* Scanlon, B.R., Levitt, D.G., Reedy, R.C., Keese, K.E., and Sully, M.J. (2005), "Ecological controls on water-cycle response to climate variability in deserts," PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA, Vol. 102, No. 17 at 6033-6038. This is because both above- and below-ground vegetation productivity intercepts and uses a significant fraction of available water, preventing this fraction from infiltrating deeper into the soil and bedrock.

Future climate changes will likely result in substantial periods of time during which the vegetation cover is reduced below that predicted by DOE. This is because human-caused climate change (*see* "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (2007) (Solomon, S., *et al.* (eds.), Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473), and "Scientific Assessment of the Effects of Global Change on the United States: A Report of the Committee on Environment and Natural Resources National Science and Technology Council" (2008) (U.S. Climate Change Science Program, Suite 250, 1717 Pennsylvania Avenue, Washington, D.C. 20006)) will likely result in temperatures at Yucca Mountain that are much hotter than assumed by DOE, as well as precipitation regimes that are both drier on average during the winter, with episodic, likely more intense, rainfall at irregular intervals, particularly in the summer or during increasingly infrequent wet winters. The hotter (5 to 10 or more degrees F warmer than present) and drier climate will make it more difficult, at least during extended dry periods, for vegetation to grow. Reduced vegetation growth will reduce the capture of soil moisture by above- and below-ground vegetation. This means that during dry periods in the future, less frequent but more intense rainfall should be able to infiltrate more freely than current, or DOE-predicted, vegetation cover allows. Thus, by assuming a particular vegetation cover at Yucca Mountain, DOE has underestimated the potential for infiltration.

The work of Scanlon, *et al.* (2005), demonstrates that non-vegetated desert sites typical of the Yucca Mountain region typically see greater deep drainage, greater groundwater recharge, and thus greater infiltration into bedrock than vegetated sites. This relates to the lack of soil water removal by plant roots, as well as above-ground water use by plants. The work of Scanlon, *et al.* (2005), at 6038, has a focus on current and past climate and vegetation change and states that "xeric vegetation can maintain dry conditions in the subsurface for millennial timescales." Of course, this means that the converse is also true, if the vegetation cover is removed, subsurface conditions will become wetter, and infiltration greater.

As described above, future anthropogenic climate change poses serious threats to the vegetation cover at Yucca Mountain that were ignored by DOE. Evidence also suggests that future human-driven climate change will also result in an accelerated ("flashier") hydrological cycle, and thus more precipitation variability and more droughts. *See* (1) Trenberth, K.E., Dai, A.G., Rasmussen, R.M., and Parsons, D.B. (2003), "The changing character of precipitation," BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY, Vol. 84, Issue 9 at 1205-1217; and (2) Allan, R.P., and Soden, B.J. (2008), "Atmospheric warming and the amplification of precipitation extremes," SCIENCE, Vol. 321, No. 5895 at 1481-1484. The same theory, observations and climate modeling also indicate that precipitation events will become more intense as the climate warms in the future. Thus, greater rainfall intensity and duration could couple with reduced vegetation cover to result in greater infiltration of water at Yucca Mountain.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsection 2.3.1.3.2.1.5 and related subsections, which state the nature of vegetation cover predicted for the future at Yucca Mountain, fail to account accurately for the possible impact of reduced vegetation cover that could result in increased rates of infiltration. Thus, they do not comply with 10 C.F.R. § 63.305(c), which requires DOE to vary factors related to climate based upon cautious but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-20 - NET INFILTRATION ALTERNATIVE CONCEPTUAL MODEL

1. <u>A statement of the contention itself</u>

SAR Subsection 2.3.1.3.3.1 and similar subsections, which state that the MASSIF model estimates net infiltration at the Yucca Mountain site based on daily water balance calculation of the near-surface soils, fails to apply alternative conceptual models to evaluate the performance of the geologic repository.

2. <u>A brief summary of the basis for the contention</u>

The Mass Accounting System for Soil Infiltration and Flow (MASSIF) model (LSN# DEN001575070) is a mass balance calculation of the surface and near-surface water that was used as the net infiltration for Yucca Mountain; however, no alternative conceptual models have been applied to represent net infiltration at Yucca Mountain.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect

compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(c) requires consideration to be given to alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and to evaluate the effects that alternative conceptual models have on the performance of the geologic repository. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

No alternative modeling approaches for net infiltration have been applied to Yucca Mountain. Perverse logic is applied in an attempt to justify this failure to meet a basic modeling criterion. For example, DOE reference document "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (01/28/2008), LSN# DEN001575070 at 6-13 notes that a number of models exist, and defines two model categories (related to the representation of subsurface water movement). The reference uses HYDRUS-1D as a single example of a Richards' equation-based model, and then dismisses it as unsuitable for use at Yucca Mountain, partly on the grounds that it is one dimensional and does not simulate surface water movement. The reference also selects the HELP model as a single example of a water balance model, and similarly dismisses it – "HELP was not used to estimate net infiltration at the Yucca Mountain site primarily because it was developed for a different type of application." *Id*. at 6-16. Because two unsuitable models were selected for consideration, and then rejected as unsuitable, DOE concludes that it need not demonstrate alternative models. The simple solution would be either to select appropriate models (and numerous candidate models exist), or to develop an alternative model for comparison.

For example, one candidate model that provides a physics-based representation of hydrological processes, is widely available (with training material), and has been used for arid and semi-arid areas in the US, is the MIKE-SHE model of the Danish Hydraulics Institute (*see* "Danish Hydraulics Institute Software Information" (09/24/2008), LSN# NEV000005416). In addition, models already available to the Yucca Mountain program could have been used for evaluation of key aspects of MASSIF model performance. For example, there has been no comparison of runoff and infiltration performance with the widely used KINEROS model, which has been used by NRC to simulate the response of both Upper Split Wash at Yucca Mountain and the adjacent Solitario Canyon watershed. *See* Woolhiser, D.A. and Fedors, R.W. (2000), "Upper Split Wash Modeling in Support of Shallow Infiltration Estimates," LSN# NRC000027373, NRC000027331, NRC000027267, all; and Woolhiser, D.A., Stothoff, S.A. and Wittmeyer, G.W. (1998), "Estimating Channel Infiltration from Surface Runoff in the Solitario Canyon Watershed, Yucca Mountain, Nevada," LSN# NRC000027227, all. In addition, the HYDRUS-1D model has a 3D version that could have been used to explore issues of temporal and spatial scaling.

The other reason given for rejecting HYDRUS-1D for application at Yucca Mountain was because it "requires substantial and detailed information about the soil structure and variability of properties," and "at the Yucca Mountain site, the available soil property dataset was limited in the number of samples and the types of measurement made." DEN001575070 at 6-15. DOE’s failure to provide appropriate data to support the necessary modeling cannot be supported as a reason for rejecting suitable alternative models, particularly as the MASSIF model also uses basic soil physical properties in its parameterization.

The peer review of net infiltration modeling, "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE) (04/01/2008), LSN# DEN001595302, Section 4.0b at 6-7 answered the question – "Were alternative modeling approaches and their results and limitations appropriately considered?" It noted that more suitable Richards' equation models were not used because "the available soil property dataset was limited." The conclusion of the peer review panel was that, "The reasons given for not using such alternative modeling approaches are not sufficient."

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.1.3.3.1 only presents the MASSIF model to estimate for net infiltration at Yucca Mountain, and fails to provide an alternative conceptual model to evaluate the performance of the geologic repository. Given the uncertainty in how the available information should be used or interpreted, DOE's failure to consider one or more alternative conceptual models results in a substantial underestimate of the uncertainty inherent in the results of the performance assessment. As a result, DOE has failed to comply with the requirements of 10 C.F.R. §§ 63.21(c)(9), 63.21(c)(15), 63.113, and 63.114(c). Therefore, pursuant to 10 C.F.R. §§ 63.31(a)(2) and (a)(3), the NRC cannot license the Yucca Mountain geologic repository.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-21 - INFILTRATION MODEL AND CHANGES IN SOIL AND ROCK PROPERTIES

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2.1.2, 2.3.1.3.2.1.3, 2.3.1.3.2.1.4 and similar subsections, which state that the MASSIF infiltration model was developed with bedrock hydraulic conductivity, soil depth and soil properties assumed to be constant for the next 10,000 years, fails to account for biogeochemical and geomorphological processes, including erosion and also fails to account for uncertainties and variabilities in parameter values.

2. A brief summary of the basis for the contention

While the modeling of net infiltration under future climate considers changes to vegetation, it neglects to consider change in soil depths, soil properties, fracture-fill material and associated rock properties due to biogeochemical and geomorphological effects, including erosion.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Even though the modeling of net infiltration under future climates as input to the TSPA includes expected changes to vegetation, no consideration is given to change in soil depth, soil properties or bedrock conductivity over 10,000 years. Such changes are expected to occur, with potentially important effects on the magnitude and spatial distribution of net infiltration. This treatment is internally inconsistent, since vegetation is known to affect soil properties. It also neglects any consideration of geomorphological change to soil depth and bedrock properties.

A key assumption of the net infiltration modeling is that "the physical properties of the soil, bedrock, and water will remain constant over the time periods being considered in the model (1 day to 10,000 years)." "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (01/28/2008), LSN# DEN001575070 at 5-4. It is recognized that soil formation processes "can significantly change soil properties (conductivity, porosity, field capacity, *etc.*)," and that "it is likely that soil erosion and deposition processes will affect soil properties and soil depth patterns over the site." *Id*. But it is assumed, without adequate justification, that such effects are only significant over periods in excess of 10,000 years.

In contrast, when considering future climate states within this period, vegetation is assumed to change. For Monsoon climate, it is assumed that current vegetation will continue, but with a changed distribution. For Glacial Transition, juniper woodland is possible, or bromegrass, which is assumed in the modeling. It is noted (DEN001575070 at 6-108) that "increased net infiltration has been correlated with the presence of brome and other grass monocultures. . . . This correlation has been attributed to increases in macroporosity and permeability. . . ." So it is recognized that changes in soil properties are likely to occur, but such effects have not been represented in the net infiltration modeling for the TSPA. In addition, there are potentially significant changes to soil depth and rock properties that are expected to occur on these time-scales due to geomorphological processes. *See, e.g.*, Stuewe, K., Robi, J., and Matthai, S. (2008), "Erosional Decay of the Yucca Mountain Crest," GEOMORPHOLOGY (in press), LSN# NEV000005187.

The introduction of changes in soil depth and rock properties would widen the range of estimates of infiltration, including those associated with episodic events. In consequence, seepage at the repository level would be altered with potentially significant effects on corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2.1.2, 2.3.1.3.2.1.3, 2.3.1.3.2.1.4 and similar subsections (which state that the MASSIF infiltration model was developed with soil depth, soil properties and bedrock hydraulic conductivity assumed to be constant for the next

10,000 years, and which fail to account for changes due to biogeochemical and geomorphological processes, including erosion) because they fail to account for uncertainties and variabilities in parameter values. Thus, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-22 - NET INFILTRATION MODEL WATER BALANCE

1. <u>A statement of the contention itself</u>

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections, which address the hydrological processes represented in the net infiltration model, are inadequate because they fail to address lateral subsurface flow and allow for the generation of surface runoff only when the soil layers are saturated.

2. <u>A brief summary of the basis for the contention</u>

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114(a), (b), (c), (e), and (g) because relevant hydrological processes – lateral subsurface flow and infiltration-excess runoff – have not been represented in the MASSIF net infiltration model.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary, paragraph (b) requires an accounting for uncertainties and variability in parameter values, paragraph (c) requires consideration of alternative conceptual models, paragraph (e) requires a technical basis for inclusion or exclusion of FEPs, and paragraph (g) requires a technical basis for models used. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Both the design of the hydrological monitoring networks at Yucca Mountain and the associated net infiltration modeling have focused on an inadequate conceptual model of hydrological process response. The only observations of soil water response at Yucca Mountain are from a network of vertical neutron probe monitoring sites, and these cannot capture lateral subsurface flow. The MASSIF model fails to represent lateral subsurface flow. Also in the model, surface runoff is generated only when the soil layers are saturated, i.e., infiltration excess runoff is excluded, despite its acknowledged importance as a key process in arid areas.

The potential importance of lateral subsurface flow was emphasized in the expert elicitation process. *See* "Unsaturated Zone Flow and Transport Modeling Expert Elicitation (UZFTEE) Project" (CRWMS M&O, 1997), LSN# NRC000010491 at, for example, 3-7 to 3-10, 4-3, and SPN-9 to SPN-10. The importance of lateral subsurface flow was reiterated by the recent independent review of the net infiltration modeling. *See* "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE) (04/2008), LSN# DEN001595302 at v). Following on from the USGS net infiltration modeling, the MASSIF model represents only vertical soil water fluxes, and thus fails to represent an important process mechanism, with implications for both the simulated volume of net infiltration and its spatial representation. A second important process response is also omitted. Surface runoff generation due to precipitation in excess of infiltration capacity is an important process response in arid areas and is often observed in the vicinity of Yucca Mountain. "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 6-6, states that "water applied to the soil surface at a rate that exceeds the infiltrability of the soil will pond at the surface and/or run off." However, in the MASSIF net infiltration model, surface runoff is generated only when the soil layers are saturated, i.e., infiltration excess runoff is excluded, despite its importance for runoff generation and the associated focusing of flow and recharge in alluvial channels.

The inclusion of these missing hydrological processes would widen the range of estimates of infiltration, including those associated with episodic events. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar and related subsections, which address the hydrological processes represented in the net infiltration model, as inadequate because they fail to address lateral subsurface flow and allow for the generation of surface runoff only when the soil layers are saturated. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), (b), (c), (e), and (g), and therefore Yucca Mountain cannot be licensed pursuant to 10 C.F.R. § 63.31.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-23 - EVALUATION OF ALTERNATIVE NET INFILTRATION MODELS

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2, 2.3.1.3.3, and 2.3.1.3.4 and similar subsections, incorrectly compare the MASSIF net infiltration model with an alternative model using other data sets.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because corroboration of the MASSIF net infiltration model through comparison with an alternative model using other data sets is flawed.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in

paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(g) requires the performance assessment to include the technical basis for models used, and to include comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE reference document "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070, Section 7.1.2 at 7-13 through 7-29 compares the MASSIF net infiltration model with the HYDRUS-1D model (a one-dimensional soil water model) on alternative, non-Yucca Mountain datasets. Lysimeter data from the Nevada Test Site and Reynolds Creek were used. However, the following flaws in these comparisons exist, some of which are pointed out by the recent independent review of the net infiltration modeling. *See* "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE) (04/2008), LSN# DEN001595302 at D-11).

- Model calibration was used to fit the model to the data.
- The treatment of boundary conditions was different in the model to those of the data.
- There was no observed occurrence of overland flow, so the ability of MASSIF to generate this component was not tested.
- For the Reynolds Creek data set, no data were available for the wetting phases, so again, testing was incomplete.

- The comparisons considered soil water storage and did not evaluate net infiltration.

In addition to these flaws, there is a fundamental problem in that the comparisons between observed and simulated responses are poor. DEN001575070, in its commentary, attempts to gloss over these discrepancies by considering average response over a year, but large and important differences occur. In addition, with regard to the Nevada Test Site Lysimeter Site, "The only interval with a noticeable difference between observed and calculated storages is during February through April of 1998. This corresponds to a series of large precipitation events . . . ." *Id*. at 7-18. Apart from the fact that large precipitation events are the most important for net infiltration, given the non-linearity of hydrological response, DEN001575070 at 7-18 shows major differences between models and data, "The calculated increase in storages is about 40mm smaller than was observed." Figures 7.1.2.1-3 and 7.1.2.2-2 show major discrepancies in the dynamics of response as well as the magnitude of storage changes. The presentation of these comparisons also demonstrates that long-term average performance for soil water storage is an inappropriate measure for this comparison. Important differences in process representation are disguised by these aggregate statistics.

Thus apart from the failure to meet the regulatory requirements for comparison with detailed process-level models, the poor performance presented shows that the MASSIF model does not provide an appropriate basis for the estimation of net infiltration. The net infiltration simulations used in performance assessment have no credibility.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2, 2.3.1.3.3, and 2.3.1.3.4 because they incorrectly compare the MASSIF net infiltration model with an alternative model using other data sets. As a result, DOE has failed to comply with 10 C.F.R. § 63.114(g), which requires the performance assessment to include the technical basis for models used, and to include comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

NEV-SAFETY-24 - PRECIPITATION DATA IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections, are flawed because there are no reliable data at Yucca Mountain to quantify snowfall, and the network of precipitation gauges is inadequate to characterize the rainfall spatial distribution for modeling of infiltration.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because observed data at Yucca Mountain are inadequate to characterize the spatial and temporal distribution of precipitation for the modeling of net infiltration or for site-specific model validation.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to the hydrology of the Yucca Mountain site and the surrounding region to the extent necessary. Section 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The modeling of net infiltration to provide inputs to the TSPA requires appropriate modeling of the spatial and temporal distribution of precipitation at Yucca Mountain for present and future climates. This requires that data are adequate to define the spatial and temporal distribution of precipitation to support the precipitation modeling. In addition, net infiltration model verification requires that precipitation data are adequate to interpret observed hydrological responses with respect to both infiltration and runoff processes.

USGS recommendations for an extensive precipitation monitoring network at Yucca Mountain were ignored. *See* "Characterization of the Meteorology for Regional Hydrology (Study Plan)" OCRWM, 1990, LSN# DN2000036430 at 3.1-52 through 3.1-55. *See also* Ambos, D.S., Flint, A.L. and Hevesi, J.A., "Precipitation Data for Water Years 1992 and 1993 from a Network of Non-Recording Gauges at Yucca Mountain, Nevada," USGS Open-File Report 95-146 (1995), LSN# DEN001273104 at 1 who state "a dense sampling network of 100-

150 monitoring sites covering the area overlying and also directly adjacent to the potential repository site was considered necessary to satisfy the data requirements for detailed 3-dimensional site-scale unsaturated flow modeling." As a result, no reliable snow data are available, and hence there is no data support for the modeling of snow depth and distribution as input to the net infiltration model. Furthermore, the inadequacy of the rainfall data has led to the use of inappropriate methods to represent the spatial distribution of precipitation as input to the net infiltration modeling for TSPA, with respect to altitude effects and spatial variability.

The lack of snow and rainfall data has also meant that validation of the net infiltration model using observed Yucca Mountain hydrological data cannot be achieved within reasonable levels of confidence. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070, Figure 7.1.3-2 at 7-33, which demonstrates that simulated runoff varies significantly depending on which of the few available rain gauges is used to define precipitation inputs, so that soil parameters cannot be validated by the available data. And in a validation of simulated daily runoff for Wren Wash (*id*., Figure 7.1.3-3 at 7-34), the "predicted" presence of snow is presented but there are no data available to validate snow simulations. "This figure illustrates the fact that a comprehensive knowledge of precipitation and temperature does not exist even when measured data exists." *Id*. at. 7-35. In other words, the monitoring of precipitation is inadequate to characterize precipitation for net infiltration modeling.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because there are no reliable data at Yucca Mountain to quantify snowfall, and the network of precipitation gauges is inadequate to characterize the rainfall spatial distribution for modeling of infiltration. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the hydrology of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

NEV-SAFETY-25 - SITE-SPECIFIC DATA IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections contain site-specific data at Yucca Mountain that are too limited to allow for validation of the net infiltration model, and those data that are available demonstrate that performance of the model is unacceptably poor for infiltration modeling.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because site-specific data are inadequate for validation of the net infiltration model and those data which do exist demonstrate the poor performance of the model.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) and (b) requires the performance assessment to include data related to the hydrology of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. 10 C.F.R. § 63.114(g) requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The MASSIF model is required to estimate net infiltration using mathematical models at appropriate time and space scales that are validated with site-specific climate, surface and subsurface information. However, site-specific data at Yucca Mountain are too limited to allow for reasonable validation of the net infiltration model, and those data that are available demonstrate that performance of the model is unacceptably poor.

In the modeling of Upper Split Wash at Yucca Mountain (which overlays the repository footprint), Woolhiser, D.A. and Fedors, R.W., "Upper Split Wash Modeling in Support of Shallow Infiltration Estimates" (CNWRA, 05/2000, Part 1 of 3), LSN# NRC000027373 at 2-18 concur – "It is not possible to draw definitive conclusions . . . because the natural watersheds probably did not have the same rainfall depth or time pattern of rainfall as that measured at the SAIC tipping bucket gage 8 located on YM crest north of the repository." "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 7-35 states "that a comprehensive knowledge of precipitation and temperature does not exist even when measured data exists." In other words, the monitoring data are inadequate to characterize precipitation (and temperature) for evaluation of hydrological response.

Stream flow data are important to evaluate a model of rainfall-runoff processes and have been used by DEN001575070 for model validation. However, the available data are incredibly limited, *see, e.g.*, *id*. Table 7.1.3-1 at 7-31, which reveals that data from 6 gauges, installed in 4 of the washes are available for just 4 years – 1993, 1994, 1995 and 1998. But in 1993 there were no data from 3 gauges, incomplete data from 2, and zero stream flow recorded from the third. In 1994 there were 3 incomplete records, and 3 recorded zero flows. In 1998 there were data from 3 sites and no data from the other 3 sites. 1995 was the most successful year, with recorded non-zero flows from 5 gauges, although data quality concerns have been expressed by NRC000027373. For example, they noted at 2-18 through 2-20 that, regarding the major event of March 1995, "The hydrograph for Upper Pagany Wash had questionable data . . . [and] . . . the peak run-off rate for Wren Wash is greater than the rainfall intensities measured at raingage 8." NRC000027373 concludes that "this suggests that Wren Wash experienced greater rainfall intensities, or that the stage rating curve used to calculate run-off rates is in error, . . . [and] . . . the reported Wren Wash runoff values . . . appear to be incorrect." The limited data, and the record of incomplete data, is an indictment of the monitoring program. Moreover, the available data do not include any extreme events. For example, Woolhiser and Fedors (CNWRA, 05/2000, Part 3 of 3), LSN# NRC000027267 at 3-21 notes that with regard to the storms of 1995, "although these storm events are the largest in the YM meteorologic station data set available for this work, their maximum intensities are nearly a factor of five lower than the intensity associated with the 100-yr return run-off event . . . ."

DEN001575070 at Section 7.1.3 demonstrates that simulated runoff varies strongly with soil saturated hydraulic conductivity (which is highly uncertain) and with the rain gauge used to define precipitation, so that the validation using stream flow is indeterminate. The best that can be said (*id*. at 7-35) is that "given the uncertainty in soil conductivity and weather data, calculations of daily runoff are fairly good." However, this statement should be seen in the context of Figure 7.1.3-15 at 7-47, for example, where for one event, simulated stream flows appear to be an order of magnitude greater than those observed, for all weather stations and soil parameter variations, and for the largest observed runoff, no flow is simulated. This is hardly "fairly good" by any objective use of the term.

Observed flow is not an adequate constraint for the validation of net infiltration. MASSIF was used on Pagany Wash in the simulation of a site where observed infiltration data were available. The results showed that "the soil saturated conductivity must be increased by an order of magnitude . . . to match the measured infiltration." DEN001575070 at 7-48. The validation also showed that the spatial distribution of net infiltration could not be constrained by the available data, "Despite the good agreement between the observed and predicted runoff in both of these scenarios, there is a pronounced difference in the spatial distribution of net infiltration for each of these scenarios . . . ." *Id*. at 7-50. So the results show that the prior assumptions of soil properties, subsequently used for TSPA, are inappropriate, and the spatial distribution indeterminate. As noted by DOE's independent review panel, "the model was not capable of representing observed infiltration beneath washes and ephemeral streams without significant calibration and alteration of assumed hydraulic properties that were used for the final infiltration estimates." "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE) (04/2008), LSN# DEN001595302 at 4).

Finally, DEN001575070 notes that the representation of uncertainty propagated through the TSPA is inadequate. "The present comparison suggests that there may be considerably more uncertainty as to where net infiltration is occurring than is represented by 40 realizations used to characterize infiltration uncertainty analysis . . . . In order to reduce this uncertainty for a given watershed more detailed information concerning the spatial distribution of soil types and properties would be required." *Id*. at 7-50. Similarly, DOE's independent review panel notes that "because of the lack of site-specific data and the use of an oversimplified model, the review panel was unable to confirm whether the model uses parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible, reasonably account for uncertainties and variabilities, and do not result in an underestimation of the long-term net infiltration." DEN001595302 at v and vi.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3, which fail to meet the requirements of 10 C.F.R. § 63.114 because the site-specific data at Yucca Mountain are too limited to allow for validation of the net infiltration model, and those data that are available demonstrate that performance of the model is unacceptably poor and that it cannot be used for infiltration modeling. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a) and (b), which requires the performance assessment to include data related to the hydrology of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. Also, these subsections do not comply with 10 C.F.R. § 63.114(g), which requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

NEV-SAFETY-26 - SOIL PROPERTIES DATA IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections fail to properly characterize model net infiltration because data to characterize soil depth and hydraulic properties are limited and thus have no credibility for use in infiltration modeling.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114(a) and (b) because available data at Yucca Mountain are inadequate to characterize the spatial distribution of soils for the modeling of net infiltration or for site-specific model validation.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in

paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Section 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Soil properties are fundamental to the modeling of net infiltration, and soil depth is one of the most sensitive parameters in the MASSIF net infiltration model for Yucca Mountain. However, data on soil depth and soil properties at Yucca Mountain are so limited that the net infiltration modeling has no credibility as evidenced by the following conclusions.

- "Sensitivity analyses presented in Sections 7.1.3 and 6.7 suggest that there may be insufficient characterization of soil properties (depth, holding capacity, and hydraulic conductivity) over the modeling domain to obtain accurate and detailed maps of net infiltration." "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 8-11.
- With respect to soil properties, "data required . . . include soil thickness. . ., soil types and layering, and corresponding soil hydraulic properties. Most of these data are not measured directly for the vast majority of the Yucca Mountain domain and must be estimated from a few measurements, including soil thickness and soil properties. There are few available measurements of soil hydraulic properties, and very little information on subsurface soil characteristics such as layering." *Id.* at 6-18.
- In fact, soil depth was found to be one of the single most sensitive parameters in the net infiltration model, but "uncertainty in the soil depth representing the zone

> of shallow soils is significant . . . [and] very few qualified measurements of soil depth were available upon which to base a model of soil depth across the site. . . . As shallow soil depth is shown to be the most significant physical parameter influencing mean net infiltration, the uncertainty in this parameter represents an important limitation on the accuracy of the mean net infiltration over the site." *Id*. at 1-4.

Soil hydraulic properties are also critically important, yet the data used for the MASSIF net infiltration modeling at Yucca Mountain have been taken by using data on soil texture to match soils from an "analogous" site at Hanford, WA, using a pedo transfer function approach. However, the Hanford soils are substantially different from those of Yucca Mountain, having a quite different pedo-genesis. *See* "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE) (04/2008), LSN# DEN001595302 at 5 and D1).

DOE has made a recent attempt to address acknowledged weaknesses with respect to soil properties, and some limited additional soil depth data from CNWRA were included. *See* "Addendum to Simulation of Net Infiltration for Present-Day and Potential Future Climates," 2008, LSN# DEN001575070 at 7-69. However, having considered this additional information, DEN001595302 at 9 discusses the "critically limited site-specific data" and concludes the "current report clearly shows the need for additional site-specific data on soil hydraulic properties and rooting depths, as well as soil distribution and soil thickness across Yucca Mountain. Without a reliable independent dataset to verify the parameters used as input to MASSIF, validation and uncertainty analyses will be inadequate." "The expert review panel assembled by ORISE concluded that the model report does not provide a technically credible spatial representation of net infiltration at Yucca Mountain." *Id*. at v.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because they fail to properly characterize model net infiltration because soil depth and hydraulic properties are limited and thus have no credibility for use in infiltration modeling. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

NEV-SAFETY-27 - ROCK PROPERTIES DATA IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections fail to provide adequate data to characterize the spatial distribution of rock properties at the soil-rock interface making it impossible to undertake infiltration modeling that is adequate for assessment purposes.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114(a) and (b) because available data at Yucca Mountain are inadequate to characterize the spatial distribution of rock properties at the soil-rock interface for the modeling of net infiltration, and major faults are ignored.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Section 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The properties of the fractured bedrock underlying the surface soils are critical for the modeling of net infiltration, since they control the entry of water into the unsaturated zone. These properties include the bulk rock and the fractures, which may be totally or partially filled with caliche. However, for the Yucca Mountain site, there are three concerns associated with those properties: (a) major faults, which are potentially important preferential flow paths, are not represented; (b) uncertainties in the mapping of the rock units are not quantified or analyzed, and (c) data are inadequate to characterize the bulk rock hydraulic properties.

With regard to first concern, some of the major fault systems at Yucca Mountain are illustrated in the LA GI Figure 5.33 at 5-153. Those faults provide potential preferential flow paths from the surface to depth, in some cases extending to more than 3000 feet below the surface, and passing through the Tuff sequence into the underlying volcanics. The net infiltration model fails to represent these fundamentally important features. Instead, model cells assume a single underlying rock type. "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 6-93, concludes that "this means that thin units may occasionally be under- or over-represented . . . ."

With regard to rock unit uncertainties, 38 bedrock units were identified from available borehole data, and where DOE considered it possible, correlated with surface exposures. Where that was not possible, proxy units were proposed. For areas underlying alluvium, generally the rock units were estimated. However, the estimate relied on the Geologic Framework Model (GFM), which did not cover areas on the northern, eastern, or southern edges of the model area. Rather, in those cases an arbitrary allocation of a single rock type (405) was made. Hence, the available data are incomplete, the distribution of rock types is inaccurate, and the associated uncertainty has not been evaluated.

Finally, with regard to bulk rock properties, bedrock saturated hydraulic conductivity is required, but the underlying data to support the estimates are inadequate. As noted by DEN001575070 at 6-97, "Few data are available to quantify either the proportion of fractures that are unfilled or the hydraulic aperture to characterize them." However, for the MASSIF net infiltration model, rock permeability depends on the product of fracture volume and fracture permeability, and fracture permeability varies with the cube of the aperture (*id*. at 6-96 and 6-97). These properties are critical for modeling the entry of water into the underlying unsaturated zone, and have a strongly non-linear effect.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because they fail to provide adequate data to characterize the spatial distribution of rock properties at the soil-rock interface making it impossible to undertake infiltration modeling that is adequate for assessment purposes. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

NEV-SAFETY-28 - NET INFILTRATION MODEL ROCK PROPERTIES UNCERTAINTY ANALYSIS

1. A statement of the contention itself

The uncertainty analysis in SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections is invalid because it uses an arbitrary criterion to exclude from consideration 70 percent of the area of interest.

2. A brief summary of the basis for the contention

In conducting its uncertainty analysis, the TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because in the modeling of net infiltration individual areas that comprised less than 15 percent of the total area were arbitrarily excluded from consideration.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to the geology, hydrology and geo chemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Section 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Bedrock bulk hydraulic conductivity is a critically important parameter for the modeling of net infiltration, since it determines the rate at which net infiltration can enter the underlying unsaturated zone. However, in the uncertainty analysis of net infiltration, only hydraulic conductivity for rock units 405 and 406 were included. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070, Table 6.5.5.1-1 at 6-153. The remaining units were excluded as their individual occurrence was less than 15 percent of the modeled area. *Id*. at 6-152. However, collectively these neglected units represent 70 percent of the modeled area. *Id*. at Table 6.5.2.5-1 at 6-95. Hence the effects of uncertainty in critical rock properties over most of the model domain have not been considered.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the uncertainty analysis in SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because it is invalid and uses an arbitrary criterion to exclude from consideration 70 percent of the area of interest. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-29 - SPATIAL VARIABILITY OF SOILS AND VEGETATION IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections use an invalid analysis because they improperly aggregate data on soils and vegetation and therefore fail to account properly for spatial variability resulting in inappropriate modeling of the amount and spatial distribution of infiltrating water.

2. A brief summary of the basis for the contention

At Yucca Mountain, soils and vegetation vary spatially in the relevant area, but the model fails to account for variation in vegetation and grossly under-represents the variability of soils and therefore fails to meet the requirements of 10 C.F.R. § 63.114.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect

compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Section 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE reference "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 6-18 acknowledges that its soils data from Yucca Mountain are severely limited:

> Data required . . . include soil thickness . . ., soil types and layering, and corresponding soil hydraulic properties. Most of these data are not measured directly for the vast majority of the Yucca Mountain domain and must be estimated from a few measurements, including soil thickness and soil properties. There are few available measurements of soil hydraulic properties, and very little information on subsurface soil characteristics such as layering.

Because of these limitations in its basic data, the spatial heterogeneity of soil properties has been grossly under-represented in the modeling of net infiltration. Specifically, 40 soil units defined by the USGS have been grouped into a set of just 4 soil units, and for each simulation uniform soil depth is assumed for each soil unit. For vegetation, the situation is even worse. For each run of the net infiltration model, a single maximum rooting depth is used for the whole model domain, and a single value of plant height is used. Such gross spatial lumping means that the process representation is incorrect, since heterogeneity can be expected to be a major influence on runoff processes and net infiltration fluxes.

Such assumptions have affected estimates not only of average net infiltration but also its spatial distribution. As the independent review of simulation of net infiltration notes, "While the model uses assumptions consistently, such as uniform soil depths and constant vegetation rooting depth, such assumptions may not be appropriate for this net infiltration simulation because they oversimplify a complex landscape and associated hydrologic processes, especially since the model assumptions have not been adequately corroborated by field and laboratory observations at Yucca Mountain." *See* "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE) (04/2008), LSN# DEN001595302 at v).

Appropriate representation of spatial variability of soil and vegetation properties would be expected to widen the range of estimates of infiltration, including those associated with episodic events. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because they use an invalid analysis because they improperly aggregate data on soils and vegetation and therefore fail to account properly for spatial variability resulting in inappropriate modeling of the amount and spatial distribution of infiltrating water. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-30 - TEMPORAL VARIABILITY IN PRECIPITATION IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections use an invalid analysis because the net infiltration modeling fails to represent correctly the temporal variability of precipitation, and hence the magnitude and spatial distribution of net infiltration is incorrect.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because the net infiltration model, which is based on a daily time step with an *ad hoc* adjustment to allow for sub-daily rainfall durations, fails to represent adequately the temporal structure of rainfall and the dynamics of the physical processes of infiltration, runoff generation and percolation.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect

compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the performance assessment to include data related to the geology, hydrology and geo chemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Section 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. 10 C.F.R. § 63.114(g) requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The net infiltration model is based on a daily time step. Some allowance for sub-daily effects is made through the specification of a sub-daily rainfall duration as a function of the daily rainfall (the estimation of rainfall duration is the subject of a separate contention). This duration is used, for example, to calculate the duration of surface water run-on to adjacent cells, and to set limits to the infiltration from one layer to another. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 6-27 through 6-29. However, the use of an average storm duration smoothes the extreme temporal variability in precipitation intensity during storms that is characteristic of convective rainfall in arid areas (as experienced at Yucca Mountain during summer storms) and is important in generating surface runoff. This temporal smoothing is not addressed in the model parameterization, and the results are therefore incorrect. In addition, the use of a daily time step to simulate moisture redistribution is an improper gross aggregation of the soil physical dynamics which have characteristic time scales of minutes to hours.

In an NRC modeling study based on Upper Split Wash, Woolhiser, D.A. and Fedors, R.W., "Upper Split Wash Modeling in Support of Shallow Infiltration Estimates" (CNWRA 05/2000 Part 1 of 3), LSN# NRC000027373 at 1-4 noted that "smoothing of rainfall intensities . . . may lead to errors, because infiltration is determined by the soil's capability to take in water at the precipitation rate." Moreover, their widely used KINEROS2 model used a 2-minute computational time-step. Thus, the use of a daily time step for net infiltration modeling is inappropriate if physically based parameters are used with no allowance for the effects of temporal aggregation on model parameterization and performance. No such work has been included in the LA, and the net infiltration results are therefore incorrect.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because they use an invalid analysis because they fail to represent temporal variability of precipitation. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. In addition, these subsections do not comply with 10 C.F.R. § 63.114(g), which requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-31 - CALIBRATION OF NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections reveal that the MASSIF net infiltration model is invalid because it requires calibration yet has not been and cannot be properly calibrated for present-day conditions.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because the net infiltration model is not fit for its purpose given its structure and the lack of available site-specific data for calibration.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in

paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. §§ 63.114(a) and (b) require the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. Section 63.114(c) requires the consideration of alternative conceptual models and to evaluate the effect of those models on the performance of the geologic repository. 10 C.F.R. § 63.114(g) requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The TSPA net infiltration estimates are based on the MASSIF net infiltration model. This model is based on crude approximations of soil water processes that are defined by physical properties, some of which some are indeterminate and all are lumped in space and time with no proper attention to parameter up-scaling. Therefore, the model parameters cannot be derived simply from estimated physical properties. For the model to have any validity, detailed calibration would be required, using extensive site-specific data. However, such data are not available for Yucca Mountain and thus calibration has not been carried out. As a result, the model results have no validity.

It is clear that selection of the net infiltration model has been determined by lack of data, rather than any objective assessment of model requirements. "Given the lack of site-specific soil depth and soil hydraulic property data, the field capacity model is an appropriate model choice, rather than using a soil physics-based model that requires better soil depth and hydraulic property data." "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 7-118. Among the problems that arise as a result of this model selection are the following:

- The implications of the use of simplified soil physics for recharge estimation have not been adequately addressed.
- Apart from a basic lack of site-specific soil hydraulic properties, there is considerable disagreement in the literature concerning the appropriate pore water pressures at which field capacity, a key parameter, is defined, *see, e.g.*, "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE)) (04/2008), LSN# DEN001595302 at D-2.
- The soil is spatially and temporally aggregated, by using a maximum of just 3 soil layers, spatially lumped on a 30 meter grid, with a 1-day time step.
- The simplified physics, combined with the spatial and temporal aggregation, means that model parameters cannot be simply related to soil physical properties, and appropriate analysis of aggregation effects has not been carried out.

The net result is that the model is empirical and must have detailed calibration. Given the lack of site-specific hydrological process studies, this is not possible. The model parameterization therefore has no data support, and the results have no validity.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 because they reveal that the MASSIF net infiltration model is invalid since it has not been and cannot be properly calibrated for present-day conditions. Thus, these subsections do not comply with 10 C.F.R. §

63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. In addition these subsections do not comply with 10 C.F.R. § 63.114(c), which requires the consideration of alternative conceptual models and to evaluate the effect of those models on the performance of the geologic repository. Nor do they comply with 10 C.F.R. § 63.114(g) , which requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

NEV-SAFETY-32 - USE OF INITIAL CONDITIONS IN NET INFILTRATION MODEL

1. A statement of the contention itself

SAR Subsection 2.3.1.3.3 and similar subsections fail to properly estimate net infiltration because they use an incorrect procedure, in which initial conditions are reset each year, and as a result, the model underestimates the effects of wet years and underestimates net infiltration.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because the MASSIF model of net infiltration incorrectly assumes initial water content to be uniformly constant for each soil type at the beginning of each water year.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in

paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. §§ 63.114(a) and (b) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. Section 63.114(c) requires the consideration of alternative conceptual models and to evaluate the effect of those model on the performance of the geologic repository. 10 C.F.R. § 63.114(g) requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

To provide inputs to the TSPA for present-day and potential future climates, DOE ran the MASSIF net infiltration model for individual years independently, with the initial conditions reset each year. This approach is incorrect, because it is likely to underestimate net infiltration following a wet year. As noted by the recent ORISE independent review, "The assumption of independent water years is neither physically appropriate nor conservative" as it is likely to underestimate the effects of exceptional years under current climates, and particularly under a Monsoon climate. "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education Report (ORISE)

04/2008), LSN# DEN001595302 at D-14). Section 6.5.7.4 of "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 attempted to evaluate the effect of this erroneous assumption by conducting a set of runs with wetter initial conditions, but that attempt fails to adequately address the issue. DEN001595302 at D-14 and D-15 concluded, "The review panel is concerned that sequentially wet climate years may not have been realistically simulated by the approaches of MASSIF and believes that the impact of sequentially wet climate years has not been adequately tested."

The effect of this will be to underestimate net infiltration. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.1.3.3 and similar subsections because they fail to properly estimate net infiltration because they use an incorrect procedure, in which initial conditions are reset each year, and as a result, the model underestimates the effects of wet years and underestimates net infiltration. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. In addition these subsections do not comply with 10 C.F.R. § 63.114(c), which requires the consideration of alternative conceptual models and to evaluate the effect of those models on the performance of the geologic repository. Nor do they comply with 10 C.F.R. § 63.114(g) , which requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-33 - APPROACH TO ESTIMATING PERCOLATION

1. A statement of the contention itself

SAR Subsection 2.3.1.3.3 and similar subsections use a model to estimate infiltration to depth that is invalid.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because the model of net infiltration has no sound physical basis and relies on arbitrary procedures and therefore cannot be used to simulate percolation to depth.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to

be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. §§ 63.114(a) and (b) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. Section 63.114(c) requires the consideration of alternative conceptual models and to evaluate the effect of those model on the performance of the geologic repository. 10 C.F.R. § 63.114(g) requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The representation in the MASSIF model of infiltration and percolation to depth in the soil profile is based on an approximate representation of soil physical processes, using the concept of field capacity. While used for other purposes such as catchment-scale simulation, the approximation is inappropriate for recharge estimation. The use of a model for net infiltration based on the concept of field capacity, which is at best a crude approximation to the underlying soil physics, has been severely criticized. For example, a panel member of the "Unsaturated Zone Flow Model Expert Elicitation Project" (CRWMS M&O (1997), LSN# NRC000010491 at DBS-4) concluded that, "regarding water balance modeling for net infiltration, I have low confidence in the Bucket model. It is inadequate for the level of detail being considered in this analysis. The concept of 'field capacity' has no physical significance."

In addition, the MASSIF net infiltration model introduces further arbitrary procedures as evidenced by "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 6-27 and 6-28, which notes that the algorithm for the calculation of the maximum amount of percolation from one soil node to an underlying soil node is given as Eq. 6.4.2-3, and from the bottom-most soil layer into the underlying rock as Eq. 6.4.2-5. In both equations the limit is given as the product of a hydraulic conductivity and a term "duration," which is defined at 6-26 as an effective precipitation duration in hours, i.e., representing the period of time that water is available at the surface of the soil. This is incorrect with respect to the calculation of percolation and has no physical basis. The documentation goes on to note that the calculation is conducted for a second time, using as a duration the difference between the day length and the precipitation duration. No justification is provided to support the validity of this arbitrary two-step calculation procedure for the simulation of net infiltration, and thus the algorithm has no demonstrable physical basis.

It can reasonably be expected that a more realistic model would widen the range of estimates of infiltration, including those associated with episodic events. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>.

This contention challenges SAR Subsection 2.3.1.3.3 and similar subsections because they use a model to estimate infiltration to depth that is invalid. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. In addition these subsections do not comply with 10 C.F.R. § 63.114(c), which requires the consideration of alternative conceptual models and to evaluate the effect of those models on the performance of the geologic repository. Nor do they comply with 10 C.F.R. § 63.114(g) , which requires the performance assessment to provide the technical basis for models used, including comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-34 - REPRESENTATION OF STORM DURATION FOR NET INFILTRATION MODELING

1. A statement of the contention itself

SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections use an incorrect representation of storm duration for modeling of net infiltration.

2. A brief summary of the basis for the contention

The TSPA fails to meet the requirements of 10 C.F.R. § 63.114 because the modeling of net infiltration assumes that daily rainfall falls as a single storm with specified sub-daily duration, which will lead to errors in the magnitude and spatial distribution of net infiltration and potentially to an underestimate of net infiltration.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. §§ 63.114(a) and (b) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In the net infiltration modeling, the selected rainfall duration is critically important, because it determines the rainfall intensity and hence infiltration and runoff processes. DOE uses a crude approach in which observed rainfall data are used to develop empirical relationships between daily rainfall and storm duration for present-day and potential future climates. A simple linear relationship is fitted by regression to relate storm duration to daily rainfall depth, and this is then used deterministically to determine storm durations associated with simulated daily rainfall.

DOE uses temporal disaggregation for various hydrological calculations, based on an estimated sub-daily storm duration that depends on the daily rainfall. DOE's representation of storm duration is flawed because it masks extreme variability in the relationship, and is therefore inappropriate. For example, for current climate, "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (05/2007), LSN# DEN001575070 at 6-57 and Figure 6.5.1.7-1, shows that a 20 mm rainfall can be associated with durations ranging from approximately 1 to 23 hours. The regression yields a value of around 10 hours. However, by ignoring the possibility of short durations, high intensity events are underestimated. This limitation leads to under-representation of high rainfall intensities, and given the non-linear nature of hydrological response, can be reasonably expected to lead to significant errors in the simulation of runoff and net infiltration. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.3.1.3.2 and 2.3.1.3.3 and similar subsections because they use an incorrect representation of storm duration for modeling of net infiltration. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that

are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-35 - EPISODIC NATURE OF INFILTRATION FLUXES IN NET INFILTRATION ANALYSIS

1. A statement of the contention itself

SAR Subsection 2.3.1.3.3 and similar subsections, which describe the net infiltration analysis, fail to consider the episodic nature of infiltration fluxes and accordingly the model used is incomplete.

2. A brief summary of the basis for the contention

The net infiltration analysis fails to meet the requirements of 10 C.F.R. § 63.114 because it fails to represent net infiltration fluxes as being dominated by rare extreme events. The input of net infiltration flux to the unsaturated zone is an annual average, sampled from 1000 years. This procedure is inappropriate because it smoothes effects of episodic net infiltration fluxes which are important for representing flow in fractures and faults within the unsaturated zone.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to

which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. §§ 63.114(a) and (b) requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary, to account for uncertainties and variabilities in parameter values, and to provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials.

Well-known characteristics of arid hydrological systems are that precipitation is infrequent, and that hydrological response is highly non-linear. As noted by the "CRWMS Management & Operating Contractor Unsaturated Zone Flow Model Expert Elicitation Project" (05/30/1997), LSN# NRC000010491 at 3-7 and 3-8, net infiltration fluxes at Yucca Mountain are expected to be dominated by extreme events. For example, the most significant events for infiltration may well be storms that occur once in 10 or 20 years or less frequently.

The MASSIF modeling "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (01/28/2008), LSN# DEN001575070, has attempted to represent the effect of extremes through simulation using 1,000-year stochastic precipitation sequences. Other contentions have addressed the adequacy of the precipitation modeling and the lack of data support (NEV-SAFETY-14, NEV-SAFETY-17, NEV-SAFETY-24, and NEV-SAFETY-34). However, a key aspect of the net infiltration modeling for TSPA is that (a) the response from extreme events, with durations of hours or days, is temporally smoothed to provide an annual flux to the unsaturated zone, and (b) only a mean value of the annual flux is provided as input to the unsaturated zone modeling. To derive the mean, 10 years are drawn from the 1,000-year sequence, but then weighted according to their occurrence probability. So a 1,000-year event is weighted by a factor of 1/1000 in defining the mean. The consequence of this procedure is that the physics of system response to these dominant extreme events is lost, by smoothing to give what is, in effect, a 1000 year average. This precludes representation of intensities likely to generate fracture flow, and is therefore incompatible with appropriate representation of the process response of the underlying unsaturated zone.

Due to the non-linearities in the net infiltration process, the explicit representation of episodic events is likely to increase net infiltration significantly. In consequence, seepage at the repository level would be altered with potentially significant changes to corrosion, radionuclide release and transport, and radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.1.3.3 and similar subsections, which describe a net infiltration analysis, because they fail to consider the episodic nature of infiltration fluxes and accordingly the model used is incomplete. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-36 - CORROBORATION OF MODEL RESULTS IN POST-MODEL VALIDATION OF NET INFILTRATION SIMULATIONS

1. A statement of the contention itself

SAR Subsection 2.3.1.3.4.2 and related subsections, which describe confidence building and abstraction of the net infiltration model for post-model development validation, do not provide an adequate basis for safety assessment because comparisons with data and alternative models are inadequate to support the net infiltration results.

2. A brief summary of the basis for the contention

The net infiltration analysis fails to meet the requirements of 10 C.F.R. § 63.114(g) because its post-model validation relies on: (a) comparisons with data from Yucca Mountain in which the data are inadequate to corroborate the model; (b) results from elsewhere that provide an inappropriate basis for comparison; and (c) comparisons with an alternative model that has an inappropriate technical basis.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. C.F.R. § 63.114(g) requires the performance assessment to include the technical basis for models used, and to include comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE reference document "Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Sandia National Laboratories, 05/2007), LSN# DEN001575070, Section 7.2.1.1 compares net infiltration model results with field data. However, it is noted (at 7-70) that "No measurements have ever been made at Yucca Mountain that directly quantify net infiltration," and (at 7-71) (a) that "the validity of comparing point measurements from boreholes with model predictions . . . are questionable . . . due to extreme scale differences," (b) that "data collected from rock/water samples at greater than a few meters depth . . . additionally has been strongly influenced by its transit through the deep UZ," (c) that "the validity of some of the UZ data and methods is questionable," and (d) that "the difficulty in comparing data from a point measurement to model predictions . . . is exacerbated by the paucity of soil depth data and soil hydraulic property data for the site."

DEN001575070 goes on to present in Figure 7.2.1.1-1 at 7-72 measured versus modeled soil depth, showing no apparent relationship between the measured and modeled results. A comparison is made (at 7-79) between neutron logging soil moisture data and modeled results, and concludes that, "As the figure shows, the comparison is not good." At 7-75, model predictions are compared with infiltration data from Pagany Wash. A reasonable comparison between modeled infiltration and infiltration inferred from borehole data could only be obtained by very large changes to soil and rock hydraulic conductivity. The effect of these comparisons is to demonstrate conclusively that the data available are inadequate to support objective evaluation of model performance, and such results as are available show the model performance to be extremely poor.

Elsewhere in DEN001575070 in Sections 7.2.1.2.1, 7.2.1.2.2 and 7.2.1.2.3 at 7-82, *et seq*., regional estimates of infiltration are used as corroboration, from Nevada and other locations in the southwestern and western United States. But given the extreme heterogeneity of infiltration, such regional estimates are not relevant to the site-specific estimation of recharge at Yucca Mountain. As noted by "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Oak Ridge Institute for Science and Education (ORISE) for US Department of Energy, Office of Civilian Radioactive Waste Management, April 2008), LSN# DEN001595302 at vi, "The fact that results are generally consistent with other regional estimates for mean net infiltration is not proof they are correct for Yucca Mountain."

Finally, with regard to infiltration estimates from the CNWRA presented in "Addendum to Simulation of Net Infiltration for Present-Day and Potential Future Climates" (Sandia National

Laboratories 2008), LSN# DEN001575070 at 7-57, this highly simplified CNWRA model does not provide an adequate basis for comparison. The model formulation, described in detail in Stothoff, "Infiltration Tabulator for Yucca Mountain: Bases and Confirmation" (CNWRA, 08/2008), LSN# NRC000029713, NRC000029696, NRC000029726, NRC000029710 and NRC000029695 is one dimensional and highly abstracted. For example, fundamentally important processes such as plant evapotranspiration and overland flow are not included in the basic model structure, but are added in a post-processing stage as empirical correction factors. Lateral subsurface flow, a major issue of concern for the UZFMEE Panel, "Unsaturated Zone Flow Model Expert Elicitation Project" (CRWMS M&O (1997), LSN# NRC000010491, is wholly excluded. The author concludes (NRC000029713 at 2-4), "The primary disadvantage of the abstraction procedure is that the abstraction may only approximately capture the full set of simulation results." Other problems include the fact that (a) the model has been driven with just 10 years of observed meteorological data, from Desert Rock, Nevada, so that extreme events are not represented, (b) the model suffers from the same deficiencies in soil and rock properties data as discussed above, and (c) that an error in the model was discovered, which affects all of the results cited in DEN001575070 (*see* NRC000029713 at xv, "Confirmatory analysis during the preparation of this report identified a mistyped value in the ITYM input file that reduces mean annual vapor density by approximately an order of magnitude. The mistyped value would be expected to increase evaporation rates by approximately 37 to 46 percent, thereby reducing bare-soil infiltration. The mistyped value has been used for all analyses using ITYM to date.")

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.1.3.4.2 and similar subsections, which describe post-model validation of the net infiltration simulations, because the validations do not support the net infiltration model performance and accordingly the modeling validation procedure used is inadequate. Thus, these subsections do not comply with 10 C.F.R. § 63.114(g) which requires the performance assessment to include the technical basis for models used, and to include comparisons with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

NEV-SAFETY-37 - NET INFILTRATION MODEL METHODOLOGY

1. A statement of the contention itself

SAR Subsection 2.3.1.3.2 and similar subsections, which present the procedure for estimating long-term mean net infiltration from the MASSIF computer simulations, use a method that is not generally accepted and is not based on sound statistical principles.

2. A brief summary of the basis for the contention

DOE calculated the long-term mean annual net infiltration using a variant of stratified sampling with strata defined by annual precipitation totals; however, this approach fails to give formal consideration to the selection of strata, and as a result, the strategy adopted may be worse than sampling 10 years at random.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized. 10 C.F.R. § 63.21(c)(15) requires an explanation of measures used to support the models used to provide the

information required in paragraph (c)(9) and that the models used must be supported by an appropriate combination of methods. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

For a given set of net infiltration model parameters, long-term mean net infiltration is estimated by running 10 years of simulated climate through the MASSIF model and calculating a weighted mean of the results. These 10 years are themselves sub-sampled from a 1,000-year climate simulation, essentially forming a stratified sample of years where the stratification is based on annual precipitation totals. The strata are determined by the percentiles of the simulated distribution of annual precipitation totals. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV01" (05/24/2007), LSN# DN2002482668, Appendix F4.1.2 at F-37. DOE says that it applies this approach to ensure that "the effects of extreme events are recognized, but given appropriate weight in the analysis." SAR at 2.3.1-42.

DOE's reasoning is confused at best and misleading at worst, because it gives the impression that somehow extremes are being considered in the uncertainty analysis when in reality extremes are not properly considered. Rather, all that DOE did with the ten separate MASSIF runs is to calculate a weighted average of the results. The end product is supposed to represent an estimate of the long-term average net infiltration for given net infiltration model parameters. As such, the selection of percentiles in Appendix F4.1.2 of DN2002482668 is arbitrary and has no clear justification. The only possible justification for using such a strategy, compared with selecting ten years at random, is to improve the precision of the resulting estimate of long-term average net infiltration. However, this will only work if the within-stratum variation in net infiltration is substantially smaller than the between-strata variation, and this has not been considered. A poor choice of strata may lead to reduced precision in estimating the long-term average compared with sampling 10 years at random.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.3.1.3.2 and similar subsections, which present the procedure for estimating long-term mean net infiltration from the MASSIF computer simulations, because they use a method that is not generally accepted and is not based on sound statistical principles. As a result, SAR Subsection 2.3.1.3.2 does not comply with 10 C.F.R. § 63.21(c)(15), which requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9) and that the models used must be supported by an appropriate combination of methods.

NEV-SAFETY-38 - PARAMETER CORRELATIONS IN NET INFILTRATION MODEL

1. <u>A statement of the contention itself</u>

SAR Subsection 2.3.1.3.3 and similar subsections, which address the treatment of parameter uncertainty in the net infiltration model, fail to properly account for parameter correlations.

2. <u>A brief summary of the basis for the contention</u>

10 C.F.R. § 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values, but with very few exceptions, parameter correlations are not considered in the uncertainty analysis and the issue is not discussed at all in SAR Subsection 2.3.1.3.3.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Subsection 63.113 have been characterized, and paragraph (c)(15) requires an

explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.113 (part of Subpart E) requires a performance assessment to be completed. 10 C.F.R. § 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The uncertainty analysis for the net infiltration model uses the technique of Latin Hypercube Sampling (LHS), which enables uncertainty distributions to be estimated using a limited number of model runs. However, a key assumption of LHS as implemented here is that the uncertain input parameters should be statistically uncorrelated. *See* McKay, M., Beckman, R., and Conover, W. (1979), "A Comparison of Three Methods for Selecting Values of Input Variables in the Analysis of Output from a Computer Code," 2 TECHNOMETRICS 21, 239-245. If this assumption fails, then the procedure will yield biased estimates of the output distribution, i.e., the distribution of long-term mean net infiltration and hence the performance assessment cannot be judged to account for uncertainties and variabilities in parameter values as required by 10 C.F.R. § 63.114(b).

Although correlations are not discussed in the SAR, they are discussed in "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV 01 ADD 01" (01/28/2008), LSN# DEN001575070. "No technical basis justifying imposing correlations between [parameters relating to the physical properties of materials] was identified. Therefore, no correlations were applied." DEN001575070 at 8-17. This implies that the default position was to neglect correlations. However, this approach is invalid because DOE fails to comply with its own statement that "[a]n adequate technical basis or bounding argument [must be] provided for neglected correlations." *Id*. at 8-16.

Without an appropriate treatment of correlations, the estimated uncertainty distributions for infiltration will be incorrect. This will in turn lead to biased estimates of the amount and chemical composition of seepage waters in the drifts with effects on corrosion, radionuclide transport, and radiological impact on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.1.3.3 and similar subsections, which address the treatment of parameter uncertainty in the net infiltration model, because they fail to properly account for parameter correlations. As a result, SAR Subsection 2.3.1.3.3 does not comply with 10 C.F.R. § 63.114(b) which requires the performance assessment to account for uncertainties and variabilities in parameter values.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's

other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-39 - TEMPERATURE LAPSE RATE VERIFICATION

1. A statement of the contention itself

SAR Subsection 2.3.1.3.2 and similar subsections, which address the temperature component of the net infiltration model, are inadequate because no attempt is made to verify the temperature lapse rate with elevation or the associated uncertainty using empirical observations.

2. A brief summary of the basis for the contention

In the temperature component of the net infiltration model, the lapse rate used to adjust for altitude does not use the available temperature data to check either the rate of change with elevation or the associated uncertainty.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized. 10 C.F.R. § 63.21(c)(15) requires that analyses and models used in the performance assessment must be

supported empirically. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The net infiltration model takes as input a time series of temperature readings at a reference elevation corresponding to the top of Yucca Mountain. Parameters derived from four weather stations are adjusted to this reference elevation, based on the assumption that temperature decreases at the rate of 1^{o}C per one hundred meters (*see* SAR at 2.3.1-39). The rate of change and the associated uncertainty are taken from a textbook, which in turn relies on some simplifying assumptions. *See* "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV 01 ADD 01" (01/28/2008), LSN# DEN001575070 at 6-11. However, DOE does not use the available temperature data to check either the rate of change with elevation or the associated uncertainty.

Infiltration is determined from the balance between precipitation and evapotranspiration. Failure to use existing local temperature information means that the evapotranspiration component could be incorrectly estimated, therefore potentially underestimating infiltration, and this in turn will lead to biased estimates of the amount and chemical composition of seepage waters in the drifts with effects on corrosion, radionuclide transport, and radiological impact on the RMEI.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.3.1.3.2 and similar subsections, which address the temperature component of the net infiltration model, are inadequate because no attempt is made to verify the temperature lapse rate with elevation or the associated uncertainty using empirical observations. Thus, SAR Subsection 2.3.1.3.2 does not comply with 10 C.F.R. § 63.21(c)(15), which requires that analyses and models used in the performance assessment must be supported empirically.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-40 - PARAMETER UNCERTAINTY TREATMENT IN NET INFILTRATION MODEL

1. <u>A statement of the contention itself</u>

The net infiltration modeling, reflected in SAR Subsections 2.3.1.3.2 through 2.3.1.3.4 and similar subsections, is invalid because the representation of parameter uncertainty in the net infiltration modeling is inadequate and the methodology for selecting net infiltration values for unsaturated zone modeling is *ad hoc*, inconsistent, and incorrect.

2. <u>A brief summary of the basis for the contention</u>

The choice of ranges and distributions to represent parameter uncertainty in the net infiltration model is not technically defensible, and the subsequent treatment of these uncertainties is incorrect.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect

compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.113 (part of Subpart E) requires a performance assessment to be completed that, in part, meets the requirements of Subpart L of Part 63. 10 C.F.R. § 63.304 (part of Subpart L) requires the performance assessment to demonstrate reasonable expectation of compliance with Subpart L by focusing on the full range of defensible and reasonable parameter distributions. 10 C.F.R. § 63.114(b) requires a performance assessment to account for uncertainties and variabilities in parameter values and provide a technical bases for their ranges. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE should use models whose parameter values, assumed ranges, probability distributions, and bounding assumptions are technically defensible and reasonably account for uncertainties and variabilities. However, throughout the net infiltration component of the TSPA, as described in SAR Subsections 2.3.1.3.2 through 2.3.1.3.4, parameter values do not reasonably account for uncertainties. In the first instance, many parameter uncertainties are neglected altogether. For example, no consideration has been given to uncertainty arising from the fact that soil physical properties have been derived from soils from a different site and pedogenesis. *See* "Independent Review of Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023, Rev. 01" (04/2008), LSN# DEN001595302 (Oak Ridge Institute for Science and Education Report (ORISE) for U.S. Department of Energy, Office of Civilian Radioactive Waste Management, April 2008) at D-1 ("[u]sing pedotransfer functions outside of their development dataset introduces substantial uncertainty because their accuracy is not known.") In addition, no consideration has been given to the effect of sub-grid heterogeneity or temporal lumping on model parameters, and no consideration has been given to the spatial variation of soil and vegetation properties within a soil class (i.e., uniform soil depths have been assumed for a given soil class and uniform rooting depth and plant height across all classes). Finally, no attempt has been made to account for uncertainty in the spatial distribution of vegetation, soil and rock properties, even though, due to lack of data, gross assumptions have been made (*e.g.*, for areas underlying alluvium, rock types were estimated or an arbitrary allocation of a single rock type was made).

Where parameter uncertainties are considered in the net infiltration component of the TSPA, the quantification of these uncertainties is often *ad hoc* and inconsistent, and in several cases, it uses procedures that are entirely incorrect. SAR Subsection 2.3.1.3.2 provides the details of the uncertainty assessment for each of the parameters in the net infiltration model. As noted in "Simulation of Net Infiltration for Present-Day and Potential Future Climates, MDL-NBS-HS-000023 REV01" (05/24/2007), LSN# DN2002482668, Section 6.5.1 and Appendix I, the basic process is to assign an uncertainty distribution to each of the parameters considered – the standard deviation of this distribution plays a critical role in the subsequent uncertainty analysis. For example, the climate parameter descriptions of the assigned distributions are given throughout DN2002482668, Section 6.5.1. However, many of the assigned distributions are flawed for the following reasons:

- The choice of distributions is often *ad hoc*, with incorrect or no justification. For example, SAR page 2.3.1-42 states that "most of the assigned uncertainty distributions for precipitation and temperature parameters are uniform distributions because there is no basis for weighting one analogue site over another, or for weighting these parameters in any shape other than uniform." This approach is flawed because the distributions would no longer be uniform under a different, equally valid model parameterization (*e.g.*, if the phase-amplitude parameterization of the temperature models is replaced with a sine-cosine parameterization).

- A further example of this flaw is the treatment of uncertainty for the upper bound monsoon climate, in which it is argued (DN2002482668 at 6-50) that for the precipitation amplitude parameters, "the potential upper-bound stations have a distribution for each parameter that may be approximated as a normal distribution, with the average and standard deviation for the two stations providing estimates for the mean and variance of the distribution. A range from one standard deviation below the lower value to one standard deviation above the upper value captures about 90% of this hypothetical distribution." One problem with this approach is that there are only two stations so the standard deviation is largely meaningless. In fact, it is simply a scaled version of the difference between the stations. Another flaw is that it is not possible to associate the result with a probability of 90% without making further assumptions that are not stated.

- The choice of distributions is inconsistent. For example, at SAR page 2.3.1-40 present-day climate parameters representing the amplitude of the seasonal cycle are assigned normal distributions for precipitation but uniform distributions for temperature. Similarly, the ranges of distributions assigned to zero-order precipitation parameters are deliberately **greater** than those observed from 10 stations, but the ranges for the corresponding temperature parameters are **equal** to those obtained from four stations. No convincing attempt is made to justify these inconsistencies.

- The assigned distributions in some cases are physically incorrect. For example, for the precipitation amplitude parameters under the monsoon climate (*see* SAR, Table 2.3.1-8), uniform distributions are assigned, and in several cases, zero lies close to the centre of these distributions. According to this approach, the average monsoon climate in the simulation experiments will have no, or very little, seasonality.

- There are cases where normal uncertainty distributions are assigned, centered on the observed estimate and with standard deviation calculated from the data. However, several of these standard deviation calculations are incorrect – the errors range from failure to account for all necessary factors to the use of incorrect mathematics. An example of the former error is a failure to account for different record lengths at different precipitation stations when calibrating altitude-precipitation relationships (*see* DN2002482668 at Appendix F2.1). Sites with more data should be given more weight in the analysis. An example of the latter error includes a totally incorrect formula for estimating the standard error of the precipitation amount-duration relationship (*see* DN2002482668, Eq. 6.5.1.7-3). This calculation has no statistical basis whatsoever, and should have been done using the textbook formula for the standard error in the slope of a linear regression model. *See* Walpole, R.E., Myers, R.H., Myers, S.L., and Ye, K., "Probability and Statistics for Engineers and Scientists, 7th ed." (Prentice-Hall, New Jersey, 2002), at 361. A second example is the use of an incorrect procedure for calculating the standard error in precipitation lapse rates (*see id*. at F-16). The lapse rate is calculated using an estimate of expected annual precipitation at the reference elevation (given in Table F-3 of DN2002482668 as 213mm), but the standard error calculation ignores the uncertainty in estimating this expected value. The effect of these errors is to undermine confidence in all of the uncertainty distributions that have been used.

- The uncertainties assigned to wind speed distributions are the same for the monsoon and glacial transition as for the present day climate. *See* SAR at 2.3.1-41 and 2.3.1-42. There is good reason to believe that the uncertainties in wind speed will be different in different climate states. No justification is provided for the assumption that they are the same.

In addition to the inappropriate quantification of parameter uncertainties, their subsequent treatment is also flawed since, as described in SAR Subsection 2.3.1.3.3, only parameters with more than 15% "standard uncertainty" are varied in deriving the distribution of net infiltration. No justification for the 15% threshold is provided. *See* DN2002482668 at Appendix I Subsection I1 at I-1. Although a sensitivity study has been carried out to examine the effects of this (*id*. at Section 7.1.4), the reported results of this study relate solely to the relative contributions of the various parameters, which does not address the key question of how sensitive are the percentiles of the overall uncertainty distribution to the threshold choice. A specific and significant example of this oversight is that the uncertainty analysis of rock properties excludes 70% of the modeled area, since most of the individual rock types fail the 15% test. It also precludes consideration of localized spatial features of major significance, such as faults. Hence when model simulations are compared to data for Pagany Wash, DN2002482668 at 7-50 notes, "the present comparison suggests that there may be considerably more uncertainty as to where net infiltration is occurring than is represented by 40 realizations used to characterize infiltration uncertainty analysis." This is a clear acknowledgement that the uncertainty analysis is inadequate.

When the distribution of net infiltration values is propagated into the unsaturated zone, it is recalibrated using the Generalized Likelihood Uncertainty Estimation procedure (GLUE).

Without the recalibration, predictions of temperature and chloride in the unsaturated zone were inconsistent with observations (*see* DN2002482668 at 2.3.2-61). Yet, the application by DN2002482668 of the GLUE methodology was appropriately rejected by the Nuclear Waste Technical Review Board (NWTRB) in 2007. "As used by DOE, the GLUE statistical procedure does not have a strong technical basis," and "the Board does not endorse the statistical modification of infiltration estimates made by DOE." NWTRB, "Technical Evaluation of US Department of Energy Yucca Mountain Infiltration Estimates" (12/15/2007), LSN# NEN000000673 at 14-15.

In sum, with regard to net infiltration, "the bounds of uncertainty have not been fully defined." DEN001595302 at 10.

SAR Subsections 2.3.1.3.2 through 2.3.1.3.4 and similar subsections fail to adequately represent parameter uncertainty because the methodology for selecting net infiltration values for unsaturated zone modeling is incorrect. As a result, SAR Subsections 2.3.1.3.2 through 2.3.1.3.4 and similar subsections are materially incomplete and inaccurate because the net infiltration process has not been properly modeled and the performance assessment does not have defensible and reasonable parameter distributions.

A biased estimate of infiltration will in turn lead to biased estimates of the amount and chemical composition of seepage waters in the drifts with effects on corrosion, radionuclide transport, and radiological impact on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the net infiltration modeling reflected in SAR Subsections 2.3.1.3.2 through 2.3.1.3.4 and similar subsections, as invalid because the representation of parameter uncertainty in the net infiltration modeling is inadequate and the methodology for selecting net infiltration values for unsaturated zone modeling is *ad hoc*, inconsistent, and incorrect. Thus, SAR Subsections 2.3.1.3.2 through 2.3.1.3.4 do not comply with 10 C.F.R. § 63.304 (part of Subpart L), which requires the performance assessment to demonstrate reasonable expectation of compliance with Subpart L by focusing on the full range of defensible and reasonable parameter distributions. Also, SAR Subsections 2.3.1.3.2 through 2.3.1.3.4 do not comply with 10 C.F.R. § 63.114(b), which requires a performance assessment to account for uncertainties and variabilities in parameter values and provide a technical bases for their ranges.

(d) Erosion

NEV-SAFETY-41 - EROSION FEP SCREENING

1. A statement of the contention itself

DOE's exclusion of land-surface erosion (FEP 1.2.07.01.0A), as reflected in SAR Subsections 2.2.1.1 and 2.2.1.2 and similar subsections, is incorrect because modeling studies and actual observations demonstrate that erosion will significantly affect infiltration and seepage fluxes at Yucca Mountain within the first 10,000 years after closure and will progressively and grossly modify the topography of the mountain within one million years.

2. A brief summary of the basis for the contention

Erosion modeling and actual observations show that down cutting into the superficial formations will significantly change the boundary conditions for infiltration and seepage modeling well before 10,000 years. As this process continues, not only will incision occur, but the whole crest of the mountain will gradually degrade, and after 10,000 years, this process will continue to depths below the elevation of the emplacement drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings that NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires a general description of the proposed geologic repository; 10 C.F.R. § 63.21(c)(11) requires an assessment of the ability of the proposed geologic repository to limit radiological exposures to the reasonably maximally exposed individual for the period after permanent closure, as required by 10 C.F.R. § 63.113(b); 10 C.F.R. § 63.21(c)(12) requires an assessment of the ability of the proposed geologic repository to limit releases of radionuclides into the accessible environment, as required in 10 C.F.R. § 63.113(c); 10 C.F.R. § 63.21(c)(13) requires an assessment of the ability of the proposed geologic repository to limit radiological exposures to the reasonably maximally exposed individual for the period after permanent closure in the event of human intrusion into the engineered barrier system, as required by 10 C.F.R. § 63.113(d); and 10 C.F.R. § 63.21(c)(14) requires an evaluation of the natural features of the geologic setting and design features of the engineered barrier system that are considered barriers important to waste isolation as required by 10 C.F.R. § 63.115. In demonstrating compliance with 10 C.F.R. § 63.113 (part of Subpart E), a performance assessment must be performed that addresses the requirements of 10 C.F.R. § 63.114(e) (also part of Subpart E), which requires that such a performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment. Specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. 10 C.F.R. § 63.115 requires that multiple barriers should be identified and described. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention along with appropriate citations of supporting scientific or factual materials</u>

The LA excludes land-surface erosion as a FEP (FEP1.2.07.01.0A), claiming that it is of low consequence. DOE bases this exclusion on two similar analyses of isotope data (Stuckless, J.S. and Levich, R.A., eds. (2007), "The Geology and Climatology of Yucca Mountain and Vicinity, Southern Nevada and California," Memoir 199, Boulder, Colorado: Geological Society of America. TIC: 259378) and concludes that erosion rates are in the range 0.4-2.7 cm in 10,000 years or 0.2-6 cm in 10,000 years, depending on the dating method used (*see* SAR Subsections 2.2.1.1 and 2.2.1.2).

However, debris flows at Yucca Mountain triggered by thunderstorms in 1984 and 2003 each locally removed much more material than suggested by these estimates. (Coe, J.A., Glancy, P.A., Whitney, J.W. (1997) "Volumetric Analysis and Hydrologic Characterization of a Modern Debris Flow Near Yucca Mountain, Nevada" GEOMORPHOLOGY, Vol. 20 at 11-28; *c.f.*, Syed, K.H., Goodrich, D.C., Myers, D.E., and Sorooshiah, S. (2003) "Spatial Characteristics of Thunderstorm Rainfall Fields and Their Relation to Runoff," JOURNAL OF HYDROLOGY, Vol. 271, Issue 1-4 at 1-21 for description of general characteristics of such events). The recent numerical modeling study of Stuewe, *et al.* (Stuewe, K., Robi, J. and Matthai, S. (2008) "Erosional Decay of the Yucca Mountain Crest," GEOMORPHOLOGY (in press), LSN# NEV000005187), using a straightforward and robust method of how much the scarps of recently active faults have been eroded, finds much higher rates than do Stuckless and Levich (2007). Stuckless and Levich's (2007) findings do not contradict these conclusions because those findings merely generalized local measurements on a small number of bedrock outcrops to the erosion process of the entire Yucca Mountain region.

Stuewe, *et al.*'s (2008) highly resolved numerical erosion model is based on a stream power approach in which the rate of erosion is assumed to be proportional to the size of the catchment as a proxy for water flux and to the square of the topographic gradient. The proportionality constants in the model are determined using the structural history of the region. Over the last 11 million years, extensional tectonics has dissected the region into a series of well-defined tilted fault blocks and the ratio of fault displacement and gully incision during this time has been used to scale the numerical model. Using these data, the model predicts that the Yucca Mountain crest will denude to the level of the proposed repository drifts within between 500,000 years and 5 million years. This prediction is based on conservative estimates for all involved parameters. Erosion may be more rapid if other processes are involved. For example, the model does not consider continuing uplift or catastrophic surface processes as have been recorded in the region. Also the model concept and the fixed spatial discretization employed promotes the formation of relatively wide V-shaped valleys, the formation of which requires removal of significantly more mass to reach the same level of incision as compared to canyons or valleys with convex flanks as are common in this part of Nevada (*cf*., Braun, J. and Sambridge, M. (1997) "Modelling Landscape Evolution on Geologic Time Scales: A New Method Based on Irregular Spatial Discretization," BASIN RESEARCH Vol. 9 No.1 at 27-52).

The two arguments presented above relating to observed current rates of erosion and the long-term effects of erosion both demonstrate that the ongoing erosion process will be of significance to safety assessment both in the period before 10,000 years and in the longer term. This arises because the process will affect (1) the infiltration flux by changing the surface morphology and soil thickness, (2) the seepage and operation of the postulated natural barrier systems (the Paintbrush Tuff may get locally completely eroded between 100,000 years and one million years), and (3) the emplacement drifts may be exposed at the Earth's surface in 500,000 years.

6. Information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges DOE's exclusion of land-surface erosion (FEP 1.2.07.01.0A), as reflected in SAR Subsections 2.2.1.1 and 2.2.1.2 and similar subsections, because modeling studies and actual observations demonstrate that erosion will significantly affect infiltration and seepage fluxes at Yucca Mountain within the first 10,000 years after closure and will progressively and grossly modify the topography of the mountain within one million years.

As indicated above, there is sufficient information to believe that DOE's exclusion of the erosion FEP (FEP 1.2.07.01.0A) on the ground of low consequence is incorrect. As a result, impacts of the repository are substantially underestimated. Thus, SAR Subsections 2.2.1.1 and 2.2.1.2 and similar subsections do not comply with numerous requirements of 10 C.F.R. 63, notably 10 C.F.R. § 63.114(e), which requires that any performance assessment performed to comply with 10 C.F.R. § 63.113 must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment. Specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

(e) Flow Through the Upper Part of the Unsaturated Zone

NEV-SAFETY-42 - VALIDATION OF UNSATURATED ZONE FLOW MODEL BY SIMULATION OF NATURAL CHLORIDE DISTRIBUTION IN PORE WATERS

1. <u>A statement of the contention itself</u>

In SAR Subsection 2.3.2.5.1.2 and related subsections the method for validating the unsaturated zone (UZ) flow model with observed chloride contents of pore waters makes an unexplained assumption about the chloride content of net infiltration; this means that uncertainties in the method have not been adequately addressed and that alternative models have not been adequately represented.

2. <u>A brief summary of the basis of the contention</u>

Consistency of modeled values with the distribution of chloride concentrations in pore waters is claimed as a validation of the site-scale unsaturated zone flow model, but firstly the modeled chloride contents depend on the contents of recharge water at the upper boundary of the model and secondly the consistency of modeled with observed data in borehole depth profiles is generally poor.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(14) requires the SAR to include an evaluation of natural features of the geologic setting that are considered barriers important to waste isolation as required by 10 C.F.R. § 63.115. One aspect of the natural barrier that is important for isolation is the low infiltration rate and consequent seepage rate into the repository and below the repository. 10 C.F.R. § 63.115(b) (part of Subpart E) requires that the description of the capability of barriers offered by natural features should take account of uncertainties in characterizing and modeling their behavior. 10 C.F.R. § 63.21(c)(15) requires that the analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, *in situ* tests, laboratory tests that are representative of field conditions. The unsaturated zone flow model has been used to assess performance and therefore the validation of this model by chloride data is being used to address this requirement. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

This contention challenges the degree of confidence that is claimed for the unsaturated zone (UZ) flow model on which is based the calculation of percolation of water towards the repository tunnels and the amount of seepage into the tunnels. It is stated that "chloride distribution in the unsaturated zone groundwater provides important information for UZ model calibration and validation." "UZ Flow Models and Submodels, MDL-NBS-HS-000006 REV03" (12/21/2007), LSN# DEN001572665, Section 6.5 at 6-64. The amount of seepage influences the physical and chemical environment in which the engineered barriers must protect the waste. In general, more seepage means that the possibilities of enhanced corrosion are greater. More seepage at, and general percolation below, repository depth also mean that any escaping radionuclides will be transported more rapidly into the saturated zone.

The distribution of chloride contents in pore waters through the unsaturated zone is simulated with a 3-dimensional gas-liquid model (*see* DEN001572665, § 6.5.2 at 6-68 through 6-79), the results from which are compared with measured chloride contents to validate the reliability of the model which is the same model that has been used to calculate percolation into the future repository. The simulation requires an input of chloride contents of incoming water or "net infiltration" at the upper boundary of the model (i.e., at the shallowest point in each depth profile). Chloride concentrations in net infiltration are much higher than in precipitation due to concentration by evapotranspiration (which is the loss of water at the surface and shallow subsurface due to evaporation and plant uptake). *See* Scanlon, B.R. (2000), "Uncertainties in Estimating Water Fluxes and Residence Times Using Environmental Tracers in an Arid Unsaturated Zone," WATER RESOURCES RESEARCH, 36.2, 395-409; and Scanlon, B.R., Healy, R.W. and Cook, P.G. (2002), "Choosing Appropriate Techniques for Quantifying Groundwater Recharge," HYDROGEOLOGY JOURNAL, 10, 18-39. The chloride concentrations and their spatial variability in the modeled profiles (*see* DEN001572665, Figures 6.5-1 to 6.5-11) are therefore strongly dependent on assumptions made about evapotranspiration, but these are not explained or justified. Therefore, the basis of the claimed validation has not been explained adequately, the uncertainties that are inherent in this method have been underestimated, and the possibility of alternative models and estimates for infiltration has not been considered.

In addition, the "goodness of fit" between the modeled depth profiles of chloride in DEN001572665, Figures 6.5-1 to 6.5-11, and the measured chloride concentrations as represented by the calculated "residuals" in DEN001572665, Table 6.5-3, are in several cases poor. "Residuals" as calculated, being the difference between the logarithms of the modeled and measured chloride concentrations, are not a rigorous or sensitive test of goodness of fit. For example, the residuals for borehole NRG-6 in DEN001572665, Table 6.5-3 do not represent how poor the fit of model to data is in DEN001572665, Figure 6.5-6. The scatter of chloride data in many of these profiles is indicative of the poor understanding of chloride distribution and therefore of infiltration compositions and rates. The same conclusion is supported by the poor match between chloride data from the ESF and modeled chloride concentrations for this lateral profile in DEN001572665, Figure 6.5-5, noting the log scale used for chloride. The sparse distribution of chloride samples and measurements along the length of the ESF is noticeable in contrast to the large number of measurements that would have been valuable to carry out a rigorous validation test of the UZ model.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

In SAR Subsection 2.3.2.5.1.2 and related subsections, the method for validating the unsaturated zone (UZ) flow model with observed chloride contents of pore waters makes an unexplained assumption about the chloride content of net infiltration; this means that uncertainties in the method have not been adequately addressed and that alternative models have not been adequately represented. Thus, these subsections do not comply with 10 C.F.R. § 63.115(b), which requires that the description of the capability of barriers offered by natural features should take account of uncertainties in characterizing and modeling their behavior or with 10 C.F.R. § 63.21(c)(15), which requires that the analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, *in situ* tests, laboratory tests that are representative of field conditions.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-43 - VALIDATION OF UNSATURATED ZONE FLOW MODEL BY CARBON-14 CONTENTS, STRONTIUM ISOTOPE COMPOSITIONS AND CALCITE MINERAL PRECIPITATE ABUNDANCES

1. A statement of the contention itself

Uncertainties in the interpretations of carbon-14 contents in the gas phase of the unsaturated zone (UZ), in strontium (Sr) contents and strontium isotope compositions of pore waters, and of the amounts of calcite mineral that have accumulated in pore spaces could be greater than calculated by DOE as described in SAR Subsection 2.3.2.5.1.2 and related subsections, and assumptions and simplifications have not been explained, so the support that these data sources give to the UZ flow model and to the low values of modeled infiltration rates is weak.

2. A brief summary of the basis of the contention

Interpretations of carbon-14 (C-14) ages from measurements of C-14 in carbon dioxide sampled from the UZ depend on what value for the C-14 activity concentration in carbon dioxide at the top of the depth profiles has been assumed and what processes of carbonate geochemistry are modeled; the resulting uncertainty in ages can be several thousands of years with a bias towards the reported ages being too old by several thousand years. Similarly, there are uncertainties and assumptions in the quantitative interpretation of Sr abundance in calcite precipitates, of the degree of apparent exchange between Sr isotope ratios in solution and minerals in different lithological units, and of the amounts of calcite that have been precipitated in pore spaces that do not support quantitatively the estimated infiltration rate of 5 mm/year.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(14) requires the SAR to include an evaluation of natural features of the geologic setting that are considered barriers important to waste isolation as required by 10 C.F.R. § 63.115. One aspect of the natural barrier that is important for isolation is the low infiltration rate and consequent seepage rate into the repository and below the repository. 10 C.F.R. § 63.115(b) (part of Subpart E) requires that the description of the capability of barriers offered by natural features should take account of uncertainties in characterizing and modeling their behavior. 10 C.F.R. § 63.21(c)(15) requires that the analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions. The unsaturated zone flow model has been used to assess performance and therefore the validation of this model by carbon-14 contents in the gas phase of the UZ, strontium (Sr) contents and strontium isotope compositions of pore waters and by the amounts of calcite mineral that have accumulated in pore spaces is being used to address this

requirement. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

This contention challenges the degree of confidence that is claimed for the unsaturated zone (UZ) flow model on which is based the calculation of percolation of water towards the repository tunnels and the amount of seepage into the tunnels. DOE states that "the criterion for the validation is that the simulated travel times for TSw units fall within the range of measured C-14 ages for the TSw units" and "the criterion for the validation is qualitative agreement between simulated Sr and the average of observations at the same elevation, and agreement with vertical trends." "UZ Flow Models and Submodels, MDL-NBS-HS-000006 REV03" (12/21/2007), LSN# DEN001572665, Sections 7.5 and 7.6. In fact, travel times obtained from the model simulations presented are higher than the measured C-14 ages. Moreover the C-14 ages are single values, not ranges of values because no uncertainties or alternative interpretative models have been considered. Interpretation of data for strontium (Sr), Sr isotopes and calcite is used to argue that the infiltration rate is low, around 5 mm/year, but uncertainties in interpretative models mean that higher infiltration rates are not excluded. The amount of seepage influences the physical and chemical environment in which the engineered barriers must protect the waste. More seepage into the drifts means that the possibilities of enhanced corrosion are greater. More seepage and general percolation at and below repository depth also mean that any escaping radionuclides will be transported more rapidly into the saturated zone.

C-14 has been measured for gas samples collected from the boreholes penetrating the UZ. By assuming that the carbon dioxide (CO_2) in the gas phase in the UZ is equilibrated with dissolved inorganic carbon in pore waters, C-14 in the gas phase has been used to calculate the travel times for co-existing UZ pore waters to move from the point of infiltration. C-14 ages have been calculated from those measurements according to the radioactive decay of the natural C-14 that would have entered the system with the infiltration at time of recharge. The calculations require an "initial C-14" content of pore waters at the point of infiltration to be assumed. This is varyingly estimated to be between 50 and 100% of the relative content of C-14 in atmospheric CO_2, but no information is given about this in DEN001572665. C-14 travel times also involve an assumption about the extent of C-14 loss to solid carbonates that precipitate from pore waters; there is no information about how this has been handled. Both of processes result in *in situ* C-14 concentrations being lowered and thus there is a tendency for estimated C-14 travel times to be too high if the assumptions are not well-founded.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

Uncertainties in the interpretations of carbon-14 contents in the gas phase of the UZ, in strontium (Sr) contents and strontium isotope compositions of pore waters and of the amounts of calcite mineral that have accumulated in pore spaces could be greater than calculated by DOE as described in SAR Subsection 2.3.2.5.1.2 and related subsections, and assumptions and simplifications have not been explained, so the support that these data sources give to the UZ flow model and to the low values of modeled infiltration rates is weak. Thus, these subsections do not comply with 10 C.F.R. § 63.115(b), which requires that the description of the capability of barriers offered by natural features should take account of uncertainties in characterizing and modeling their behavior. Nor do they comply with 10 C.F.R. § 63.21(c)(15), which requires that the analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-44 - FLOW IN THE UNSATURATED ZONE FROM EPISODIC INFILTRATION

1. A statement of the contention itself

Screening of FEP 2.2.07.05.0A "Flow in the UZ from episodic infiltration" from performance assessments in SAR Subsection 2.2.1.2 and related subsections and as specifically stated at SAR Table 2.2-3 at 2.2-127 is not justified.

2. A brief summary of the basis of the contention

Chlorine-36 data from wall rock of the ESF tunnels indicate that fast pathways for infiltration of water from episodic high-precipitation events persist through the UZ to repository depth, with local infiltration rates of considerably more than the assumed average flux of 32 mm/yr.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those FEPs of the site that are expected to materially affect compliance with Section

63.113 have been characterized, and the extent to which they affect waste isolation. 10 C.F.R. § 63.114(e) (part of Subpart E) requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Episodic infiltration with transiently high rates of downwards movement of pore waters would potentially change the overall rate of infiltration and seepage at and below repository depth. The rate of seepage at repository depth is pertinent to both the corrosion rate of the engineered barriers and the rate of radionuclide transport through the lower part of the unsaturated zone (UZ). Understanding the patterns of past infiltration, including episodic high rates, and using evidence of this to calibrate the hydrogeological model of the unsaturated zone and the upper bounds of infiltration, should be included in the performance assessment.

Episodic flow of anomalous transiently high rates of infiltration through the unsaturated zone has been excluded by screening on the basis that this process has low consequence. This is based on the argument that such episodic flows are damped in the non-welded Paintbrush Tuff unit (PTn) so that variability of infiltration rates below the PTn are not significantly different from the longer term averages, i.e. "have a maximum range of about 17 mm/yr."

Leachates of rock samples from fractures intersecting the walls of the ESF tunnel were found to contain significant quantities of chlorine-36 which can be attributed to infiltration that entered the UZ after the start of atmospheric bomb testing, i.e., about 50 years ago. The chlorine-36 evidence has recently been discounted because it was not possible to replicate the results, but this is not adequate justification to reject the evidence totally and it appears to be accepted in FEPs. *See* "Features, Events, and Processes for the Total System Performance Assessment: Analyses, ANL-WIS-MD-000027 REV00" (03/06/2008), LSN# DEN001584824.

As an illustration, it is estimated that such a chlorine-36 anomaly in a fracture at ESF depth would indicate a local infiltration rate of around 1350 mm/yr (i.e., percolation through 450 meters of UZ, typical porosity 0.15, infiltration of Cl-36 in precipitation at ground surface at ~50 years ago). The existence of the Cl-36 anomaly indicates that damping of infiltration pulses by the matrix-capillary action suggested for the PTn fails to operate at least locally. There is no firm evidence that positively confirms that the Cl-36 evidence should be discounted, so the precautionary approach is to accept the Cl-36 is evidence of fast pathways.

It has been suggested that the quantity of water that penetrates the PTn through fast pathways is about 1% of total infiltration. (*See* "MDL-NBS-HS-000006 Revision 02, UZ Flow Models and Submodels," DIRS 180273 (11/01/2004), LSN# DN2001630459 at 6-19). Another modeling study has also indicated that episodic infiltration pulses entering fault zones in the UZ are less damped than infiltration through other pathways and have a finite probability of penetrating to the base of the PTn. *See* Zhang, K., Wu, Y.-S., and Pan, L. (2006)"Temporal Damping Effect of the Yucca Mountain Fractured Unsaturated Rock on Transient Infiltration Pulses." JOURNAL OF HYDROLOGY, Vol. 327 at 235-248. DOE claims that this small proportion of potential "fast pathway" infiltration is negligible. This is not consistent with the Cl-36 evidence. Although the proportion of infiltration that this could represent is not quantifiable, it suggests that the effect of episodic infiltration of large amounts of infiltration, albeit locally, through the UZ to repository depth should not be discounted by this screening exclusion of the FEP. The range of potential impacts on performance assessment of such fast pathways and locally high episodic infiltration rates should have been considered.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

Screening of FEP (Feature/Event/Process) 2.2.07.05.0A "Flow in the UZ from episodic infiltration" from performance assessments in SAR Subsection 2.2.1.2 and related subsections and as specifically stated at SAR Table 2.2-3 at 2.2-127 is not justified. Thus, these subsections do not comply with 10 C.F.R. § 63.114(e), which requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to

each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-45 - EFFECTS OF EPISODIC FLOW

1. A statement of the contention itself

SAR Subsection 2.3.2.4.2.1.2, and similar subsections, which states that one of the two primary large-scale processes that prevents or substantially reduces the movement of water through the unsaturated zone (UZ) and into the emplacement drifts of the repository is the damping of episodic pulses of precipitation and infiltration, fails to provide an appropriate technical basis for excluding FEP 2.2.07.05.0A (Flow in the UZ) from episodic infiltration as the effects of horizontal heterogeneity have not been adequately represented.

2. A brief summary of the basis for the contention

SAR Subsection 2.3.2.4.2.1.2 fails to properly model the Paintbrush nonwelded unit (PTn), resulting in an underestimation of vertical flow and preferential flow within the PTn formation, and therefore the assumption that the PTn is able to attenuate episodic events sufficiently to allow the assumption of constant flow in the underlying Topopah Spring Tuff formation is inappropriate.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those FEPs of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and the extent to which they affect waste isolation. 10 C.F.R. § 63.114(e) (part of Subpart E) requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 2.3.2.4.2.1.2 at 2.3.2-79 provides the following discussion as the basis for excluding the effect of flow in the unsaturated zone (UZ) from episodic infiltration (FEP 2.2.07.05.0A) in the Total System Performance Assessment (TSPA):

> The net surface infiltration at the bedrock surface (on top of the TCw unit) is conceptualized as episodic, with significant pulses occurring only once every few years (SNL 2008a, Section 6.5.7.5). Spatially and temporally variable pulses of moisture percolate rapidly through the highly fractured tuffs of the TCw. However, at the TCw-PTn interface – where welded tuffs grade sharply into nonwelded tuffs – flow behavior changes from fracture dominated to matrix dominated flow. The highly porous PTn unit attenuates the episodic infiltration flux significantly such that the net episodic surface infiltration, once crossing the PTn, can be approximated as steady state (SNL 2007a, Section 6.2.2).

To support this assumption various modeling studies have been undertaken, as described in SAR Subsection 2.3.2.4.2.1.2 and DOE reference document "UZ Flow Models and Submodels," MDL-NBS-HS-000006 Rev. 03, Add. 01 (Sandia National Laboratories, Las Vegas, NV, 2007), LSN# DEN001572665, Section 6.9 at 6-124, to consider the impact of episodic flow events in the Paintbrush nonwelded unit (PTn). However, these studies have not considered the effect of horizontal heterogeneity in the PTn layer, in particular the large number of faults present in the rock formation.

The PTn is characterized by stratigraphic variations and structural complexity at all scales, and based on detailed line surveys of the Exploratory Studies Facility, it is estimated that there is a mean fault spacing of 2.23 ± 2.14 m and a mean fault dip of 69 ± 14° for the PTn as a whole. *See* Manepally, *et al.* (CNWRA 2007), "The Nature of Flow in the Faulted and Fractured Paintbrush Nonwelded Hydrogeological Unit," LSN# NRC000029300. Such faulting can result in permeability anisotropy, as observed at analogue sites, markedly reducing lateral flow diversion and increasing vertical flow. *See* Evans, J.P. and Bradbury, K.K. (2004), "Faulting and Fracturing of Nonwelded Bishop Tuff, Eastern California: Deformation Mechanisms in Very Porous Materials in the Vadose Zone," VADOSE ZONE JOURNAL, Vol. 3, Issue 2 at 602-623. Studies of transient flow using 3-D modeling (*see* Zhang, *et al.* (2006), "Temporal Damping Effect of the Yucca Mountain Fractured Unsaturated Rock on Transient Infiltration Pulses" (LSN# DN2002209213) at 235-248), which use calibrated parameter values obtained from steady-state analyses (*see* Wu, *et al.* (2003), "A Mountain-Scale Model for Characterizing Unsaturated Flow and Transport in Fractured Tuffs of Yucca Mountain" (LSN# NEV000004201, all); and "UZ Flow Models and Submodels," MDL-NBS-HS-000006, Rev. 02 (Bechtel SAIC Co., Las Vegas, Nevada, 2004) (LSN# DN2001630459), as changed by LSN# DN2002143063), have not used an appropriate representation of the characteristics of the PTn formation. As a result, they have over-estimated the amount of lateral flow to major faults (i.e., Ghost Dance and Solitario Canyon) while underestimating vertical flows within the bulk of the PTn formation. In contrast, analyses of episodic events based using 1-D models (*see* Zhang, *et al.*, op. cit.; Guerin (2001), Tritium and ^{36}Cl as Constraints on Fast Fracture Flow and Percolation Flux in the Unsaturated Zone at Yucca Mountain" (LSN# DEN001089956) at 257-288), although not incorporating the effects of large scale flow diversion, have failed to account for these larger scale effects of heterogeneity on flow pathways through the PTn as they utilize local scale parameter values derived from the 3D site scale model (*see* "Calibrated Properties Model," MDL-NBS-HS-000003, Rev 00 (OCRWM 2000), LSN# DEN000676205). Therefore, they underestimate the degree of preferential flow present with the PTn layer.

In both cases, therefore, the assumption that the PTn is able to attenuate episodic events sufficiently to allow the assumption that flow in the underlying Topopah Spring Tuff formation, within which the proposed repository is located, is constant (over the duration of a given climate state) is inappropriate . This is particularly true in the area of the southern footprint of the proposed repository, where the thickness of the PTn layer is only a few tens of meters (*see* SAR Figure 2.3.2-4).

A changed pattern of flow will affect both the amount and composition of water impacting on the engineered barrier system with consequences for rates of corrosion and release and transport of radionuclides from degraded waste packages.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE statements in SAR Subsection 2.3.2.4.2.1.2, which in turn relies on DOE reference document LSN# DEN001572665, which excludes flow in the unsaturated zone from episodic infiltration, because it fails to adequately represent the effects of horizontal heterogeneity in the Paintbrush nonwelded unit (PTn). As a result, SAR Subsection 2.3.2.4.2.1.2 is both materially incomplete and inaccurate because it does not provide a sufficient technical basis for excluding an FEP (i.e., flow in the unsaturated zone) from the performance assessment, and thus fails to properly evaluate resulting radiological exposures or releases from the Yucca Mountain repository. Therefore, SAR Subsection 2.3.2.4.2.1.2 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(9), 63.113, and 63.114(e), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-46 - EXTREME EVENTS UNDEFINED

1. A statement of the contention itself

SAR Subsection 2.1.2.1.2, and similar subsections, which state that one of the two primary large-scale processes that prevents or substantially reduces the movement of water through the unsaturated zone (UZ) and into the emplacement drifts of the repository is the damping of episodic pulses of precipitation and infiltration, fail to provide an appropriate technical basis for excluding FEP 2.2.07.05.0A (Flow in the UZ from episodic infiltration) as the effects of extreme events on UZ flow have not been considered in a rigorous manner because an extreme event has not been formally defined or appropriately modeled.

2. A brief summary of the basis for the contention

SAR Subsection 2.1.2.1.2 fails to properly represent the effects of extreme infiltration events on UZ flow and seepage as such events have not been defined in a rigorous and physically defensible manner and the resulting assumption that flow in the UZ from episodic infiltration can be excluded is unjustified.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those FEPs of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and the extent to which they affect waste isolation. 10 C.F.R. § 63.114(e) (part of Subpart E) requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 2.3.2.4.2.1.2 at 2.3.2-79 provides the following discussion as the basis for excluding the effect of flow in the unsaturated zone (UZ) from episodic infiltration (FEP 2.2.07.05.0A) in the Total System Performance Assessment (TSPA):

> The net surface infiltration at the bedrock surface (on top of the TCw unit) is conceptualized as episodic, with significant pulses occurring only once every few years (SNL 2008a, Section 6.5.7.5). Spatially and temporally variable pulses of moisture percolate rapidly through the highly fractured tuffs of the TCw. However, at the TCw-PTn interface – where welded tuffs grade sharply into nonwelded tuffs – flow behavior changes from fracture dominated to matrix dominated flow. The highly porous PTn unit attenuates the episodic infiltration flux significantly such that the net episodic surface infiltration, once crossing the PTn, can be approximated as steady state (SNL 2007a, Section 6.2.2).

To support this assumption various modeling studies have been undertaken, as described in SAR Subsection 2.3.2.4.2.1.2 and DOE reference document "UZ Flow Models and Submodels," MDL-NBS-HS-000006 Rev. 03, Add. 01 (12/21/2007), LSN# DEN001572665, Section 6.9 at 6-124, to consider the impact of episodic flow events in the Paintbrush nonwelded unit (PTn). However, the episodic events used in these studies were arbitrarily selected, both in terms of intensity, duration and frequency. This means that no formal definition of an extreme event, in terms of its rarity, intensity profile and duration, has been provided. The key scenario that has been used to defend this position assumes that the annual average infiltration, summed over a period of 50 years, occurs at a uniform rate over one week. *See* Wu, *et al.* (2000), "Capillary Barriers in Unsaturated Fractured Rocks of Yucca Mountain, Nevada," LBNL-46876 (10/02/2000), LSN# DEN001337908; Guerin (2001), "Tritium and ^{36}Cl as Constraints on Fast Fracture Flow and Percolation Flux in the Unsaturated Zone at Yucca Mountain" (03/20/2001), LSN# DEN001089956 at 257-288; and Zhang, *et al.* (2006), "Temporal Damping Effect of the Yucca Mountain Fractured Unsaturated Rock on Transient Infiltration Pulses" (02/10/2006), LSN# DN2002209213 at 235-248. Whilst this approach may appear to represent an extreme event, no support for this, such as an estimated return period and whether it has any physical basis for representing such an event, has been provided.

The failure to provide an return period on the episodic infiltration studies is a crucial omission given the extremely long time periods (in excess of 10,000 years) required for the safety assessment of the proposed repository, during which an event of extreme rarity (i.e., once in a thousand years) is highly likely to occur. This is particularly poignant as it has been noted by the "Civilian Radioactive Waste Management System, Management and Operating Contractor, Unsaturated Zone Flow Model Expert Elicitation Project" ((05/30/1997), LSN# DN2002326148, all), that net infiltration fluxes at Yucca Mountain are expected to be dominated by extreme events, with significant infiltration perhaps occurring as infrequently as once in 10 or 20 years.

In regard to the physical basis of these episodic scenarios, the majority of studies have been based on 1-dimensional representations, which ignore the effects of heterogeneity and flow focusing. The one study that has investigated this using a 3-dimensional distributed model (*see* Zhang, *et al.* (2006), DN2002209213, all) did so by making use of linearly scaled distributed mean infiltration rates (*see* " MDL-NBS-HS-000023 REV 00, Simulation of Net infiltration for Present-Day and Potential Future Climates" (11/09/2004), LSN# DN2001629759 at 6-61) to provide the distribution of infiltrations associated with an event comprising 50 years accumulated infiltration in one week. The conversion of rainfall to infiltration is a highly non-linear process (*see* Pruess, *et al.* (1999), "Alternative Concepts and Approaches for Modeling Flow and Transport in Thick Unsaturated zone of Fractured Rocks" (04/03/1998), LSN# DEN001261352, all). Therefore, such an approach is non-physical, as it ignores the connection of rainfall, surface runoff, infiltration and subsurface flows due to the physical properties of the geological media. Furthermore, by neglecting the high degree of non-linearity that would be expected to occur under such extreme conditions it greatly underestimates the range of infiltration rates associated with such an event. Consequently, conclusions drawn from these analyses are considered to be unreliable and do not support the assumption that the presence of the PTn unit is sufficient to ensure that flow in the Topopah Spring welded tuff, and hence seepage into drifts situated in this unit, can be considered to be time invariant over the durations associated with specific climate states.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.1.2.1.2, which in turn relies on DOE reference document DEN001572665, which excludes flow in the unsaturated zone from episodic infiltration, because it fails to properly represent the effects of extreme infiltration events on UZ flow and seepage as such events have not been defined in a rigorous and physically defensible manner. As a result, SAR Subsection 2.1.2.1.2 is both materially incomplete and inaccurate because it does not provide a sufficient technical basis for excluding an FEP (i.e., flow in the unsaturated zone from episodic events) from the performance assessment, and thus fails to properly evaluate resulting radiological exposures or releases from the Yucca Mountain repository. Therefore, SAR Subsection 2.1.2.1.2 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(9), 63.113, and 63.114(e), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-47 - PHYSICAL BASIS OF SITE SCALE UNSATURATED ZONE FLOW

1. A statement of the contention itself

SAR Subsection 2.3.2.4 and similar subsections, which describe the development of the site-scale UZ flow model, fail to provide a reasonable physical basis to support the characterization of the subsurface hydraulic properties at the site of the proposed repository and do not, therefore, provide reliable bounding estimates for drift seepage calculations under present and future climates.

2. A brief summary of the basis for the contention

The layers of fractured and faulted tuffs that comprise the geology of Yucca Mountain are highly complex and heterogeneous and the parametric relationships used to represent their hydraulic properties, along with the general assumption of horizontal homogeneity, lack a physical basis, and therefore, fail to provide an adequate characterization of the site.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those FEPs of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and the extent to which they affect waste isolation. 10 C.F.R. § 63.114(c) (part of Subpart E) requires that any performance assessment should consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository. Also, 10 C.F.R. § 63.114(e) (part of Subpart E) requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission. Finally, 10 C.F.R. § 63.114(g) (part of Subpart E) requires provision of the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.2.4.1.1.1, at 2.3.2-41, states that subsurface flow at Yucca mountain "occurs in a heterogeneous system of layered, fractured volcanic rocks." In order to estimate seepage fluxes into emplaced waste canisters in this heterogeneous system, the behavior of infiltrating water at the surface has to be quantified using numerical models. These models have to capture the non-linear responses associated with unsaturated flow at a variety of scales. The primary approach selected for deriving spatial fluxes for use within the TSPA is to represent the geological environment as a dual-permeability continuum. It is therefore assumed that the fractures and volcanic tuff matrix within which these fractures exist can be considered as two discrete and separate continua that occupy the same spatial volume. Flow can occur simultaneously through both of these continua, as well as from one to the other. In order to justify this simplified representation of the physical system, it has been assumed that the hydraulic behavior of the fractures occurs in a similar way to flow in pores in a porous medium (*see* SAR Subsection 2.3.2.4.1.1.2 at 2.3.2-42) and therefore flow continuity in both fracture and matrix continua can be represented using Richards' equation (*see* SAR Subsection 2.3.2.4.1.1.2 at 2.3.2-43). Thus, the flow of water per unit area in a given direction at a specific point is given by the product of the negative gradient of the total hydraulic potential and the unsaturated hydraulic conductivity at that point. As hydraulic conductivity is a function of capillary pressure, parametric relationships are used to characterize this behavior. For the fractured volcanic tuffs at Yucca Mountain, the relationship proposed by van Genuchten (van Genuchten, M.T. (1980) "A Closed-Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils," SOIL SCIENCE SOCIETY OF AMERICA JOURNAL, Vol. 44(5) at 892-898), coupled with a modification developed by Liu, *et al.* (Liu, H.H., Doughty, C. and Bodvarsson, G.S. (1998) "An Active Fracture Model for Unsaturated Flow and Transport in Fractured Rocks," WATER RESOURCES RESEARCH, Vol. 34(10) at 2633-2646), to reflect the varying contact area of wetted fractures with the rock matrix that occurs with changes in fracture saturation, has been assumed (the active fracture approach). Consequently, the representation on flow in fractures is based on a conceptual understanding developed from research on soils and soil physics (Pinder, G.F., Huyakorn, P.S. and Sudicky, E.A. (1993), "Simulation of Flow and Transport in Fractured Porous Media," In: Bear, J., Tsang, C-F and de Marsily, G. (eds.) Flow and Contaminant

Transport in Fractured Rock, San Diego, Academic Press, at 406). However, there is no formal justification for this assumption, and indeed, there is doubt about the validity of this approach, particularly in relation to the physical basis of the parametric relationships employed to characterize the system.

A detailed comparison of the active fracture model with a discrete fracture network (DFN) model showed that, although the introduction of the active fracture model improved the ability of the dual continuum approach to predict flow (and also tracer transport) under unsaturated conditions, it was found that, at the 1 m^3 scale, the active fracture parameter varied between 0.38 and 1.0 depending on flow conditions, "suggesting that that the AFC parameter was not sufficient to fully capture the complexity of the flow processes in a 1 m^3 discrete fracture network" (Seol, Kneafsey and Ito (2006), "An Evaluation of the Active Fracture Concept in Modeling Unsaturated Flow and Transport in a Fractured Meter-Sized Block of Rock," VADOSE ZONE JOURNAL 5 at 1–13).

A further problem with the representation used to characterize unsaturated flow arises from the use of Mualem's model (Mualem, Y. (1976) "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media," WATER RESOURCES RESEARCH, Vol. 12(3) at 513-522) for deriving the relative hydraulic conductivity relationship from the van Genuchten parametric relationship used to relate fracture water content with water potential. In order to use Mualem's model, it is assumed that the "m" and "n" parameters in the van Genuchten equation are related. Specifically, van Genuchten assumed that $m = 1 - 1/n$. However, there is no physical basis for this assumption. Furthermore, Mualem introduced a so called "tortuosity" term where the degree of saturation, Se, was raised to the power L in order to represent the effect of tortuous flow pathways within the porous medium. Mualem assumed a value of 0.5 for L. This value was also assumed by van Genuchten, and therefore, has been used in the characterization for Yucca Mountain (as shown in SAR Subsection 2.3.2.3.3.1 at 2.3.2-25). However, there is no justification for this assumption. Work by Schaap and Leij (2000) (Schaap, M.G. and Leij, F.J. (2000) "Improved Prediction of Unsaturated Hydraulic Conductivity with the Mualem-van Genuchten Model," SOIL SCIENCE SOCIETY OF AMERICA JOURNAL, Vol. 64 at 843-851) on 235 soil samples has shown that there is no benefit in setting L = 0.5 and improved results can be obtained by calibrating it to observed hydraulic conductivity data. Generally Schaap and Leij (2000), *id.*, found that negative values of L achieved better fits to the data. At increasingly negative pressures, the relative hydraulic conductivity function becomes sensitive to the changes in the value of L. At a water potential of -100,000 Pa, typical of those observed at Yucca Mountain ("UZ Flow Models and Submodels, MDL-NBS-HS-000006 REV 03" (2007), LSN# DEN001572665, Section 6.9 at 6-37) changing L from 0.5 to -0.5 results in a change in relative conductivity of around two orders of magnitude.

The lack of a physical basis for at least three of the parameters (active fracture parameter, m and L) used to characterize the spatially varying hydraulic properties of the tuffs at Yucca mountain is compounded by the assumption that, within a particular geological stratum, all the parameters are horizontally homogeneous (*see* SAR Subsection 2.3.2.4.1.1.4 at 2.3.2-45). This is based largely on field observations of matrix properties ("Analysis of Hydrologic Properties Data, ANL-NBS-HS-000042 REV 00" (10/04/2004), LSN# DN2001623088 at 6-1). However, there are no grounds for assuming that the processes that led to the extensive fracture formation in the rock matrix produced essentially identical properties over tens of square kilometers. This is demonstrated in the marked variation in saturated hydraulic properties derived from pneumatic tests. *Id*. at 6-10.

The combined effect of at least three of the parameters used to characterize the hydraulic properties of the UZ at Yucca mountain not having a proper physical basis along with the assumption that these and other properties are constant within a given geological layer, means that the calibrated 3D site-scale flow fields, which are the basis for calculations of seepage fluxes into waste canisters, are unreliable. Furthermore, there is no justification for assuming that these parametric values, and hence the simulated flow fields obtained using them, are valid when modeling flows under future climate states with different infiltration rates. Thus, the potential for corrosion of the containers, radionuclide release and impact on the reasonably maximally exposed individual have not been properly assessed. This arises because the full range of relevant FEPs and the characteristics of those FEPs have not been adequately addressed, alternative (and more appropriate) conceptual models of the system have not been considered, and an inadequate technical basis is given for the model that has been used.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.3.2.4 and similar subsections, which describe the development of the site-scale UZ flow model, because they fail to provide a reasonable physical basis to support the characterization of the subsurface hydraulic properties at the site of the proposed repository and do not, therefore, provide reliable bounding estimates for drift seepage calculations under present and future climates. Specifically, the full range of relevant FEPs and the characteristics of those FEPs have not been adequately addressed; alternative, and more appropriate, conceptual models of the system have not been considered; and an inadequate technical basis is given for the model that has been used. Thus, this contention challenges that SAR Subsection 2.3.2.4 and similar subsections do not comply with 10 C.F.R. §§ 63.114(c), (e) and (g).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-48 - MULTI-SCALE THERMAL-HYDROLOGIC MODEL

1. A statement of the contention itself

SAR Subsection 2.3.5.4, and similar and related subsections, which state or assume that the multi-scale thermal-hydrologic model accurately models the movement of heat and mass (liquids and gases) from the in-drift to the mountain scale, are incorrect because they ignore the presence of ground support items, especially the hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts that are to be installed in the emplacement drifts.

2. A brief summary of the basis for the contention

DOE's model for the movement or transport of heat and mass from the drift scale to the mountain scale utilizes the multi-scale thermal-hydrologic model (composed of six sub-models), but ignores the planned installation of hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts that will have the largest effect at the smallest scale, that is, the drift scale.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, part 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(a) (also part of Subpart E) requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Comprised of six sub-models, the multi-scale thermal-hydrologic model is DOE's primary modeling method to describe the movement of heat and mass (primarily gas) with time from the smallest scale (drift) to the largest scale (mountain). However, DOE's modeling effort in this regard completely ignores ground support items that are to be installed in the emplacement drifts for safety purposes and to facilitate installation of drip shields or even removal of the waste canisters for whatever reason.

The ground support items ignored by DOE are the ungrouted super Swellex-type stainless steel rock bolts. There are 10 rock bolts in each vertical cross section of any emplacement drift, spaced at a distance of 1.25 m and penetrating into the drift wall a distance of 3 m. The vertical sections with rock bolts are spaced 1.25 m apart horizontally to yield a 1.25 m square grid pattern of rock bolts. This installation pattern will result in thousands of these rock bolts being installed throughout the emplacement drifts of the repository. The rock-bolt hole is about 54 mm in diameter and the Swellex-type rock bolt is expanded with a few hundred pounds of water pressure to snugly fill this hole. The SAR does not clearly indicate whether the rock bolt ends are to be sealed or left open, or if sealed how much water, if any, may be left inside the expanded bolts.

At the smallest scale, the drift scale, the rock bolts will affect heat transfer from the drifts because a 3 m deep hole with about a 2+ inch diameter will be filled with a thin stainless steel tube with an unknown amount of water sealed inside. The metal will facilitate heat transfer into the rock, and if any water remains inside, each bolt may act as a small-scale heat pipe. The small-scale heat pipe boils water at the drift wall end, which then condenses at the deeper end in the drift wall, and eventually drips back to repeat the cycle. Only the six upward tilted rock bolts (from the drift wall) may show this behavior since the other rock bolts are either sub-horizontal or downward tilted. In any event, the rock bolts have the potential to change the heat distribution around the emplacement drifts, gas phase movement, and saturation patterns in the drift wall rocks. The Bernold-type liners have a small effect on drift-wall emissivity, increasing the temperature differences between the drift wall and the drip shield, but the effect is within the variations of the thermal conductivity of the drift wall rocks. *See* "Total System Performance

Assessment Data Input Package for the Multiscale Thermohydrologic Model; TDR-TDIP-NF-000008_REV00_Final" (04/01/2007), LSN# DN2002426865 at 47.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

The hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolt are described in SAR Subsection 1.3.4. The multi-scale thermal hydrologic modeling is discussed in SAR Subsection 2.3.5.4, as well as enclosed subsections and included references. The multi-scale thermal hydrologic model leaves out small-scale features, such as the ground support items, because DOE believes that these man-made features have little or no effect on the outcomes of the modeling. However, DOE's assumption has not been demonstrated with the rock bolts that are to be used underground in the emplacement drifts. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-49 - MODELS OF FLUID MOVEMENT IN THE UNSATURATED ZONE

1. A statement of the contention itself

SAR Subsections 2.3.2 and 2.3.5.3, and similar and related subsections, which state or assume diametrically opposed methods of aqueous fluid movement in the unsaturated zone, are inconsistent with each other and will give rise to different chemical results for seepage waters that may contact the engineered barrier systems at some future time.

2. A brief summary of the basis for the contention

SAR Subsection 2.3.2 (unsaturated zone flow) states that fracture flow in densely welded fractured volcanic tuffs of the TSw is the predominate method of aqueous fluid transport; however, SAR Subsection 2.3.5.3 (near-field chemistry) assumes that plug-flow is the dominant mode of aqueous fluid flow. These two methods are inconsistent with each other and will lead to different chemical results for seepage waters that will eventually contact the EBS in the future after repository closure. The adoption of two contradictory models means that the overall model is demonstrably inconsistent and invalid, and cannot be relied upon.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(a) (also part of Subpart E) requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.5.3 identifies plug flow as the method of aqueous fluid flow in the unsaturated zone for the densely welded fractured tuffs of the Topopah Spring Tuff (TSw), which is the geologic unit that will contain the emplacement drifts of the repository. Plug flow implies that there is total equilibration between water flowing in the fractures and that in the matrix of the rock. DOE supports plug flow with modeling (finite element heat and mass, or

FEHM), strontium isotope analyses of pore water samples and mineral samples, and uranium isotopic studies. The near field chemistry model is based on this plug flow and is used to predict the chemistry of seepage waters that might contact the engineered barrier systems (EBS) in the post 10,000-year period after closure of the repository.

In contrast, however, SAR Subsection 2.3.2 proposes that fracture flow of aqueous solutions is the predominate method of fluid flow in the same densely welded and fractured tuffs of the TSw. If fracture flow is the dominant means of fluid flow, then there is limited interaction between waters in the fracture and presumably older, more stagnant waters held in the matrix of the rock. Limited interaction between fracture and matrix waters suggests that their chemistry is different. SAR Subsection 2.3.2.2.2.1 defends limited fracture-matrix interaction of waters with field and laboratory observations, chloride concentrations in the different geologic units in the unsaturated zone and perched water bodies, and bomb pulse chloride-36 isotopic compositions at the ESF level in the repository rocks. Analogous field studies at Rainier Mesa on the Nevada Test Site, and in the Negev Desert are also used to support limited fracture-matrix interactions of water. If water flowing in fractures has limited interaction with matrix water, as stated in SAR Subsection 2.3.2.2.2.1, then their chemical compositions will differ, and the chemistry of matrix water cannot be used to predict the potential chemistry of seepage water the may contact EBS components at some time in the future (up to one million years after repository closure).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

DOE has given two incompatible methods for aqueous fluid transport in the unsaturated zone. Specifically, SAR Subsection 2.3.2 contends that fracture flow predominates in the unsaturated zone and that there is limited fracture-matrix interaction. However, SAR Subsection 2.3.5.3 proposes and supports a plug-flow model where there is total equilibrium between aqueous liquids flowing in the fractures and the matrix. Supporting references are given in the associated sections and subsections of the SAR. Given that there are neither samples nor chemical analyses of aqueous fluids flowing in the fractures; DOE has only indirect evidence to support assumptions in the near-field chemistry model. The adoption of two contradictory models means that the overall model is demonstrably inconsistent and invalid, and cannot be relied upon. In these circumstances, SAR Subsections 2.3.2 and 2.3.5.3 do not comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, 10 C.F.R. § 63.114(a), which requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform.

Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-50 - ALTERNATIVE DISCRETE FRACTURE FLOW MODELS

1. A statement of the contention itself

SAR Subsection 2.3.2.3 and similar subsections demonstrate that DOE has not used discrete fracture network models, which are in common use for representing water flows and radionuclide transport in fractured rocks in the context of post-closure performance assessments; as a consequence, the DOE approach introduces a bias into the TSPA because flow focusing and peak flow rates are underestimated whereas transport distances and times are overestimated.

2. A brief summary of the basis for the contention

DOE models fluid flow in the unsaturated zone and seepage into the emplacement drifts at Yucca Mountain using only a dual porosity conceptual model that poorly approximates fracture flow and solute transport, and DOE improperly dismisses discrete fracture models that rely on fewer assumptions, are more readily calibrated, and better represent the measured physical characteristics at Yucca Mountain.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(g) requires DOE to provide a technical basis for models used in the performance assessment including, in particular, laboratory testing. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The dual porosity (DP) abstraction of fracture flow that DOE uses to assess infiltration fluxes and seepage introduces a strong bias into the TSPA. The abstraction underestimates flow focusing and peak flow rates and overestimates transport distances and times. Although basic analysis of flow focusing by highly permeable lenses indicates that flow-focusing factors of >100 should be common for fractures or faults with similar length-over-width ratios (*see, e.g.*, Phillips, O.M. (1991), "Flow and Reactions in Permeable Rocks," Cambridge Univ. Press, at 66 ff), DOE’s bulk estimates of flow focusing do not exceed a factor of 6 (*see* SAR Fig. 2.3.3-22(a) at 2.3.3-121). The likely explanation for these gross underestimates appears to be the volume averaging of all fracture data during the construction of the DP model. This methodology assumes that essential properties like fracture length and aperture have representative averages. This is unrealistic (*cf*., Bonnet, E., Bour, O., Odeling, N. E., Davy, P., Main, I., Cowie, P., and Berkowitz, B. (2001), "Scaling of Fracture Systems in Geological Media," REVIEWS OF GEOPHYSICS Vol. 39, No. 3 at 347–383), and fails to sufficiently weight data outliers. The DOE DP approach still rests on the assumptions made in the original formulation by Barenblatt, G.I., Zheltov, Y.P. and Kochina, I.N. (1960), "Basic Concepts in the Theory of Seepage of Homogeneous Fluids in Fissurized Rocks," PRIKLADNAYA MATEMATIKA I MEKHANIKA Vol. 24, No. 5 at 852-864 (in Russian); J. APPLIED MATHEMATICS AND MECHANICS (PMM), Vol. 24, No. 5 at 1286-1303 (English)), including the one that a representative elementary volume (REV) can be identified for the fractured rocks at Yucca Mountain such that for greater length scales the flow properties of the rocks are scale invariant. This assumption is not supported by the field observations of Dunne, W.M., Ferrill, D.A., Crider, J.G., Hill, B.E., Waiting, D.J., La Femina, P.C., Morris, A.P. and Fedors, R.W. (2003), "Orthogonal Jointing During Coeval Igneous Degassing and Normal Faulting," GSA BULLETIN, Vol. 115, No. 12 at 1492–1509 who describe open fractures and faults on all length scales at Yucca Mountain, including clusters/fracture corridors. These fractures and faults are not adequately represented in the DP models.

Discrete fracture network (DFN) models are available that could overcome these deficiencies and avoid use of the assumptions associated with the volume averaging that the DP approach relies on. DFN models capture the fracture geometry explicitly using unstructured grids that are adaptively refined to represent small and large features at the same time. *See, e.g.*, (1) Kim, J.G. and Deo, M.D. (2000), "Finite Element, Discrete-Fracture Model for Multiphase Flow in Porous Media," AICHE JOURNAL Vol. 46, No. 6 at 1120-1130; (2) Juanes, R., Samper, J. and Molinero, J. (2002), "A General and Efficient Formulation of Fractures and Boundary

Conditions in the Finite Element Method," INT. J. NUM. METH. ENG., Vol. 54 at 1751-1774; (3) Monteagudo, J.E.P. and Firoozabadi, A. (07/2004), "Control-Volume Method for Numerical Simulation of Two-Phase Immiscible Flow in 2D and 3D Discrete-Fracture Media," WATER RESOURCES RESEARCH, Vol. 40, W07405; and (4) Matthai, S.K. Mezentsev, A. and Belayneh, M. (2007), "Control-Volume Finite-Element Two-Phase Flow Experiments Represented by Unstructured 3D Hybrid Meshes," SPE 93341, Proceedings of the SPE Reservoir Evaluation and Engineering, at 740-756. Differences in the flow behavior of the fractures and the rock matrix can be accounted for because these are separate flow domains.

SAR Subsection 2.3.3.2.3.7.1 at 2.3.3-47 states that DFN models were not considered because of a scarcity of information on fracture geometry and hydrologic properties on the scale of individual fractures. However, outcrop and drift geologic mapping has provided the necessary geostatistical fracture data (*see, e.g.*, Dunne, *et al.*, 2003). The essential fracture-scale hydrological properties were also established in field tests and laboratory experiments conducted in the frame of DOE’s characterization of Yucca Mountain, *see* Nicholl, M.J. and Glass, R.J. (2005), "Infiltration into an Analog Fracture: Experimental Observations of Gravity-Driven Fingering," VADOSE ZONE JOURNAL Vol. 4, No. 4 at 1123-1151, and references therein. Thus, data of sufficient quality to build realistic DFNs are available for Yucca Mountain.

SAR Subsection 2.3.3.2.3.7.1 at 2.3.3-47 argues that a comparison between a DFN and a simplified DP conducted by Finsterle, S. (2000), "Using the Continuum Approach to Model Unsaturated Flow in Fractured Rock," WATER RESOURCES RESEARCH, Vol. 36, No. 8 at 2055-2066. Washington, D.C.: American Geophysical Union, TIC: 248769 (2000), provided "consistent" results. However, this study is inconclusive because the so-called DFN is based on a regular 2D grid with an entirely synthetic, highly unrealistic permeability structure with no resemblance to fractured rock, and the DFN-fracture continuum model matches obtained for selected properties are poor and restricted to a steady-state seepage scenario.

DOE's DP abstraction substantially underestimates the degree of flow focusing and the maximum seepage flux through the repository and therefore underestimates the dose to the RMEI.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.3.2.3 and similar subsections because they demonstrate that DOE has not used DFN models, which are in common use for representing water flows and radionuclide transport in fractured rocks in the context of post-closure performance assessments; as a consequence, the DOE approach introduces a bias into the TSPA, because flow focusing and peak flow rates are underestimated whereas transport distances and times are overestimated. Thus, these subsections do not comply with 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. It also does not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, or with 10 C.F.R. § 63.114(g), which requires DOE to provide a technical basis for models used in the performance assessment including, in particular, laboratory testing.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-51 - POTENTIAL CONVECTIVE SELF ORGANIZATION OF 2-PHASE FLOW

1. A statement of the contention itself

The simulation grids used in the mountain-scale thermal-hydrologic seepage model (*see* SAR Subsections 2.3.2 and 2.3.3.3.1, and similar subsections; *see also* Wu, Y.S.; Mukhopadhyay, S.; Zhang, K.; and Bodvarsson, G.S. (2006), "A Mountain-Scale Thermal-Hydrologic Model for Simulating Fluid Flow and Heat Transfer in Unsaturated Fractured Rock," JOURNAL OF CONTAMINANT HYDROLOGY, Vol. 86 at 128-159, Fig. 2 are too coarse to capture the spatial self-organization and accompanying localization of single and two-phase (steam and condensed water) flow which is likely to occur in the thermal loading phase of the repository.

2. A brief explanation of the basis for the contention

The TSPA thermal-hydrologic model is discretized too coarsely to capture the two-phase flow and saturation patterns and the localization of the flow that is expected to occur in the thermal phase following repository closure. Specifically, due to its limited spatial resolution and the integrated finite-difference dual continuum discretization employed, which only permits the resolution of a single fracture and matrix saturation value per grid cell, the TSPA mountain-scale model cannot resolve localized flow or convective circulation in the plane of permeable faults. It follows that DOE's TSPA TH simulation results are inconclusive.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. Demonstration that the contention is material to the findings that NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(g) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. Concise statement of the facts or expert opinions supporting the contention along with appropriate citations of supporting scientific or factual materials

SAR Subsection 2.3.3 introduces the multi-scale thermal-hydrologic TSPA-LA model for mountain- to drift-scale processes (*see* SAR Subsection 2.3.5.4.1) and a hierarchy of 3D finite volume simulation grids (*see, e.g.*, SAR Figs. 2.3.2-10 and 2.3.5-26) refined to a most detailed spatial resolution of 81 m perpendicular to the repository drifts in the repository region. *See* "Multiscale Thermohydrologic Model, ANL-EBS-ML-000049, Rev. 03, Add. 02" (01/29/2008), Sandia National Laboratories, LSN# DEN001575312, sections 6.2.4-6.2.9 at 6-23 through 6-50 and sections 6.2.14[a] to 6.2.17[a] at 6-11[a] through 6-17[a]. This resolution is too coarse to capture drift-scale flow instabilities that may originate at the drift scale but can grow in size to the repository scale.

Higher resolution thermal-hydrologic simulation models and simulation results exist only in 2D (*see* SAR Subsection 2.3.3.3.3.1 and Fig. 2.3.3-35) and do not contain first-order heterogeneities like faults, although many of these intersect the repository drifts (*see, e.g.*, Potter, C.J.; Day, W.C.; Sweetkind, D.S.; and Dickerson, R.P. (2004), "Structural Geology of the Proposed Site Area for a High-Level Radioactive Waste Repository, Yucca Mountain, Nevada" GSA BULLETIN, 116:7/8 at 858–879).

However, thermally driven fluid/steam convection around faults and the buoyancy driven two-phase fluid flow that will occur after repository closure are three-dimensional coarsening instabilities which – even in the absence of permeability heterogeneity – can produce highly localized flow and self-organized saturation patterns that need to be resolved in three dimensions (*cf.*, Murphy, H.D. (1979), "Convective Instabilities in Vertical Fractures and Faults," JOURNAL OF GEOPHYSICAL RESEARCH, 84, B11, 6 at 6121-6130; and Lopez, D. and Smith, L. (1995), "Fluid Flow in Fault Zones: Analysis of the Interplay of Convective Circulation and

Topographically Driven Groundwater Flow," WATER RESOURCES RESEARCH, Vol. 31, No. 6 at 1489-1503), and on the scale of the repository because their size (and the size of regions where steam and water travel on separated pathways) can reach this scale (*see* Gascoyne, M. and Wuschke, D.M. (1997), "Gas Migration Through Water-Saturated, Fractured Rock: Results of a Gas Injection Test," J. HYDROLOGY, 196, 1-4 at 76-98). The mountain scale thermal-hydrologic TSPA-LA model is not fit for this purpose.

Thus, the TSPA thermal-hydrologic model is discretized too coarsely to capture the two-phase flow and saturation patterns and the localization of the flow is expected to occur in the thermal phase following repository closure.

Nowhere in the SAR or LA as a whole are there reports of results from mesh convergence tests to demonstrate that a mountain-scale model with enhanced resolution will give the same flow patterns and degree of flow localization. The 3D maintain scale model (*cf*., Wu, *et al.* (2006) and Wu, Y.S., Lu, G., Zhang, K., and Bodvarsson, G.S. (2007), "An Integrated Modeling Approach for Characterizing Multiphase Flow, Chemical Transport, and Heat Transfer in Fractured Reservoirs, SPE-106996," Presented at the SPE Europe/EAGE Annual Conference and Exhibition held in London, United Kingdom, June 11-14, 2007, and uncertainty assessment by Ye, M., Pan, F., Wu, Y.S., Hu, B., Shirley, C., and Yu, Z. (2007), "Assessment of Radionuclide Transport Uncertainty in the Unsaturated Zone at Yucca Mountain," ADVANCES IN WATER RESOURCES, Vol. 30 at 118–134) has the dimensions 8000 x 4000 x 1500 m, and grid-block sizes ~80-400m. In geothermal proxy systems with similar rock types and fracturing, steam and water tend to flow on spatially segregated pathways and steam discharge is often localized to sub-meter scale vents (*see, e.g.*, O'Sullivan, M.J., Modvarsson, G.S., Pruess, K. and Blakeley, M.R. (1985), "Fluid and Heat Flow in Gas-Rich Geothermal Reservoirs, LBL-16329," Soc. Pet. Eng. J., Vol. 25 No. 2 at 215-226). This is true also for gas discharges in fractured crystalline water-saturated rocks (Gascoyne and Wuschke, 1997).

Due to its limited spatial resolution and the integrated finite difference dual continuum discretization employed, which only permits the resolution of a single fracture and matrix saturation value per grid cell, the TSPA mountain-scale model cannot resolve the types of localized flow described above or convective circulation in the plane of permeable faults (Lopez and Smith, 1995). It follows that DOE's TSPA thermal-hydrologic simulation results are inconclusive.

6. Information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

The simulation grids used in the mountain-scale thermal-hydrologic seepage model described in SAR Subsections 2.3.2 and 2.3.3.3.1 are too coarse to capture the spatial self-organization and accompanying localization of single and two-phase (steam and condensed water) flow which is likely to occur in the thermal loading phase of the repository. Therefore, these subsections do not comply with 10 C.F.R. § 63.114(g), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as with outputs of detailed process-level models. In this case, the models used do not have an adequate technical basis to simulate the phenomena that they purport to represent.

NEV-SAFETY-52 - EBS AND NEAR-FIELD MODELING APPROACH

1. A statement of the contention itself

SAR Subsection 2.3.3 and similar subsections describe a sequential and unidirectional linked modeling approach for the engineered barrier system and near-field that is untenable because that modeling approach suppresses emergent behavior and ignores the influence that coupled repository processes have on one another.

2. A brief summary of the basis for the contention

If waste is emplaced into Yucca Mountain, the thermal structure of the engineered barrier system (EBS) and near-field during the thermal phase will be the product of the interplay of diffusive (thermal conduction) and advective (gravity-driven infiltration and steam convection) heat and mass transfer processes coupled with phase transitions (boiling, evaporation and condensation). Ignoring the influence that these processes have on the seepage flux, as the DOE modeling approach does by using seepage as a boundary condition read from a lookup table, is untenable because seepage and its focusing are directly (i.e., first-order) dependent on saturation as affected by the circulating steam. Conversely, steam flow and circulation depend on the seepage flux and its distribution.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. Demonstration that the contention is material to the findings that NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section § 63.113 have been characterized, and Section 63.21(c)(15) requires an explanation of the measures used to provide the information required in Section 63.21(c)(9). In demonstrating compliance with 10 C.F.R. § 63.113 (part of Subpart E), a performance assessment must be performed that addresses the requirements of 10 C.F.R. § 63.114(a) (also part of Subpart E) to include data related to the geology, hydrology, and geochemistry of the Yucca Mountain site, Section 63.114(b) to account for uncertainties and variabilities in parameter values and provide the technical basis for parameter ranges, and Section 63.114(f) to provide the technical basis for models used. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. Concise statement of the facts or expert opinions supporting the contention along with appropriate citations of supporting scientific or factual materials

The current DOE approach to EBS and near-field modeling assumes that the highly coupled, complex phenomena operating at Yucca Mountain can be predicted by decomposition into a collection of component process models which, when coupled sequentially – using one model's output as input for the next one – provide a predictive model of near-field behavior. *See* SAR Subsection 2.3.3 and Fig. 2.3.3-2. However, this logic holds only for weakly coupled relatively simple systems for which cause and effect chains and process interfaces are well established.

DOE assumes, for example, that calibrated seepage fluxes, including focusing leading to spatial flux variations in the vicinity of the drifts, can be computed in isolation. *See* SAR Subsection 2.3.3 and Fig. 2.3.3-2. In its EBS and near-field modeling approach, DOE then reads these fixed values in from a lookup table. During the thermal phase of the repository, steam/moist air is likely to convect in the fractured rock mass surrounding the emplacement drifts, and where this steam condenses it can bring the seeping water to boiling, changing its path. Additionally, moisture from below the drifts may become entrained into this circulation, locally increasing the seepage flux. All such instabilities, which will increase in magnitude with time, and the resulting process interactions, are suppressed by DOE's sequential modeling approach and abstraction of the seepage flux which prescribes process linking as opposed to letting it evolve as an emergent coupled feature of the model.

Furthermore, many of the laboratory findings and numerical modeling results obtained for small-scale flow processes at Yucca Mountain point to process interdependencies that are inconsistent with how these processes are abstracted in the most-recent TSPA models. Examples of such small-scale processes include vaporizing water flow (*see* Pruess, K. (1997) "On Vaporizing Water Flow in Hot Sub-Vertical Rock Fractures," TRANSPORT IN POROUS MEDIA, Vol. 28 at 335-372), gravity-driven infiltration instabilities in the fractures (*see* Nicholl, M.J., Glass, R.J., and Wheatcraft, S.W. (1994) "Gravity-Driven Infiltration Instability in Initially Dry Non-Horizontal Fractures," WATER RESOURCES RESEARCH, Vol. 30 No. 9 at 2533-2546), and film flow (*see* Tokunaga, T.K. Wan, J. and Sutton, S. (2000) "Transient Film Flow on Rough Fracture Surfaces," WATER RESOURCES RESEARCH, Vol. 36 at 1737-1746). Ignoring such important physics has resulted in an over-calibrated model with little predictive capabilities. Like the underground-discovery of anthropogenic ^{36}Cl near a fault in the repository (*see*

Campbell, K., Wolfsberg, A., Fabryka-Martin, J., and Sweetkind, D. (2003), "Chlorine-36 Data at Yucca Mountain: Statistical Tests of Conceptual Models for Unsaturated Zone Flow," JOURNAL OF CONTAMINANT HYDROLOGY, Vol. 62/63 at 43-61), there are already several examples where "*the actual behaviour of the geological system forced the re-examination of this conceptual model*" (*cf*., Long, J.C.S. and Ewing, R.C. (2004), "Yucca Mountain: Earth-Science Issues at a Geologic Repository for High-Level Nuclear Waste," ANNUAL REVIEW OF EARTH AND PLANETARY SCIENCE, Vol. 32 at 363-401).

In an appropriate fully coupled engineered barrier system and near-field model, the vigorous recirculation of liquid water and steam would strongly alter the composition and amount of water interacting with the engineered barriers. Corrosion would be enhanced and flows of water and steam into the degraded waste packages could be increased leading to increases in radionuclide releases and doses to the RMEI.

6. Information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.3.3 and similar subsections because they describe a sequential and unidirectional linked modeling approach for the engineered barrier system and near-field that is untenable because that modeling approach suppresses emergent behavior and ignores the influence that coupled repository processes have on one another. Thus, these subsections do not comply with 10 C.F.R. § 63.114(a), which requires any performance assessment to include data related to the geology, hydrology, and geochemistry of the Yucca Mountain site, Section 63.114(b), which requires any performance assessment to account for uncertainties and variabilities in parameter values and provide the technical basis for parameter ranges, and Section 63.114(f) which requires any performance assessment to provide the technical basis for models used.

NEV-SAFETY-53 - APPLICATION OF THE FRACTURE MATRIX DUAL CONTINUUM MODEL TO ALL UNSATURATED ZONE FLOW PROCESSES

1. A statement of the contention itself

In SAR Subsection 2.3.2.3 and similar subsections, DOE states that fluid flow in the fractured rock at Yucca Mountain is modeled using the dual continuum idealization in conjunction with the Van Genuchten relative permeability/capillary pressure model for the fractures, but experimental studies show that multiphase fluid flow through larger aperture fractures cannot be described by this model and this calls into question all of DOE's conclusions regarding in-drift seepage and infiltration rates.

2. A brief summary of the basis for the contention

DOE uses the dual-continuum approach to model fracture and matrix flow. Hence two sets of properties (i.e., relative permeability and capillary pressure curves), along with other intrinsic properties (*e.g.*, permeability, porosity, density, fracture geometric parameters, and transport properties) are needed for the fracture and matrix systems, respectively. The Van Genuchten (VG) model of relative permeability and capillary pressure functions is used to describe variably saturated flow in both fracture and matrix continua. Although this may be appropriate for small aperture fractures at a sufficiently small rate of flow, research by DOE on fluid infiltration into the fractures at Yucca Mountain identified flow behavior that cannot be captured using the VG approach. This deficiency implies that infiltration rates predicted by DOE may be orders of magnitude too low. Also, the DOE dual continuum model makes predictions for the behavior of the fracture-matrix composite that are completely inconsistent with corresponding experiments, and discrete fracture and matrix models.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings that NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(g) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-

compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations of supporting scientific or factual materials

DOE uses the dual-continuum approach to model fracture and matrix flow. This means that all flow predictions are based on two sets of properties: relative permeability and capillary pressure curves. The Van Genuchten (VG) model of relative permeability (Van Genuchten, M.Th. (1980), "A Closed-Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils," SOIL SCIENCE SOCIETY OF AMERICA JOURNAL, Vol. 44 at 892-898) and capillary pressure functions is used for these, and therefore, for the variably saturated flow in both fracture and matrix continua.

Although the VG model may be appropriate for small aperture fractures at a sufficiently small rate of flow, research undertaken for DOE on fluid infiltration into the fractures at Yucca Mountain (*see* Persoff, P., and K. Pruess (1995), "Two-Phase Flow Visualization and Relative Permeability Measurement in Natural Rough-Walled Rock Fractures," WATER RESOURCES RESEARCH, Vol. 31 No. 5 at 1175–1186; Nicholl, M.J., Glass, R.J., and Wheatcraft, S.W. (1994), "Gravity-Driven Infiltration Instability in Initially Dry Non-Horizontal Fractures," WATER RESOURCES RESEARCH, Vol. 30, No. 9 at 2533-2546; Nicholl, M.J., and R.J. Glass (2005), "Infiltration into an Analog Fracture: Experimental Observations of Gravity-Driven Fingering," VADOSE ZONE JOURNAL, Vol. 4 at 1123–1151) identified flow behavior that cannot be captured by the VG approach. This deficiency (compare VG relative permeability curve for water with that seen in instable infiltration experiments) and the inability of the VG-based Yucca Mountain model to deal with fingering in the fracture planes imply that infiltration rates predicted by DOE may be orders of magnitude too low. Also, the DOE dual continuum model predictions for the behavior of the fracture matrix composite are inconsistent with corresponding experiments (*see* Kwicklis, E.M., Thamir, F., Healy, R.W. and Hampson, D. (1998), "Numerical Simulation of Air- and Water-Flow Experiments in a Block of Variably Saturated, Fractured Tuff from Yucca Mountain, Nevada," U.S. Geological Survey Water Resources Investigations Report 97-4274, 64 p.; Rangel-German, E.R. and Kovscek, A.R. (2000), "Matrix fracture interaction in single matrix blocks," Proc. 25th Wkshp. Geotherm. Res. Eng., Stanford U., Stanford, CA, January 24-25, 2000, SGP-TR-165; Rangel-German. E. R., Akin, S. and Castanier, L. (2006), "Multiphase-Flow Properties of Fractured Porous Media," JOURNAL OF PETROLEUM SCIENCE AND ENGINEERING, Vol. 51 at 197-213) where fracture saturation at high flow rates does not reflect a capillary pressure equilibrium with the surrounding rock, and with results from discrete fracture and matrix models (*see* Matthai, S.K. Mezentsev, A. and Belayneh, M. (2007), "Finite Element—Node-Centered Finite-Volume Two-Phase-Flow Experiments With Fractured Rock Represented by Unstructured Hybrid-Element Meshes," SPE 93341-PA, SPE RESERVOIR EVALUATION & ENGINEERING, Vol.10, No. 6 at 740-756).

Furthermore, the DOE model concept for capillary pressure in the variable aperture fractures at Yucca Mountain is based on the assumption of invasion percolation (*see* Pruess, K., and Tsang, Y.W. (1990), "On Two-Phase Relative Permeability and Capillary Pressure of Rough-Walled Rock Fractures," WATER RESOURCES RESEARCH, Vol. 26, No. 9 at 1915-1926; Persoff and Pruess (1995)). The fallacy of this conceptualization when applied to meter-scale fractures, as opposed to the pore-scale, is that constrictions meters away from the point of interest are supposed to have an influence on the local capillarity of the fracture. This can hold only if there is an infinite amount of time for equilibration and in the absence of gravitational forces. These, however, are the main driver for fluid infiltration and seepage at Yucca Mountain.

Finally, all the relative-permeability experiments relating to fractures have identified flow regimes marked by saturation patterns that grow to the scale of the experimental apparatus. These coarsening instabilities suggest that the observed behavior is scale dependent. This has not been investigated by DOE.

6. Information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

In SAR Subsection 2.3.2.3 and similar subsections, DOE states that fluid flow in the fractured rock at Yucca Mountain is modeled using the dual continuum idealization in conjunction with the Van Genuchten relative permeability/capillary pressure model for the fractures, but experimental studies show that multiphase fluid flow through larger aperture fractures cannot be described by this model and this calls into question all of DOE's conclusions regarding in-drift seepage and infiltration rates. Thus, these subsections do not comply with 10 C.F.R. § 63.114(g), which requires that any performance assessment used to demonstrate compliance with § 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). In this case, the technical basis of the model used is flawed, and comparisons with experimental data or with other, alternative models reveal these flaws.

NEV-SAFETY-54 - CONSTITUTIVE RELATIONSHIPS IN THE YUCCA MOUNTAIN INFILTRATION, THERMO-HYDROLOGIC, AND TSPA MODELS

1. A statement of the contention itself

Whereas DOE's infiltration-, seepage- (*see* SAR Subsection 2.3.3 and related subsections), thermohydrologic- (*see* SAR Subsection 2.3.3.3 and related subsections), and TSPA models (SAR Subsection 2.3.3.4 and related subsections) are designed for steady-state conditions, infiltration, thermally driven flow, and fracture seepage have all been documented to be episodic and this means that conditions at Yucca Mountain lie outside the range of applicability of DOE's models.

2. A brief summary of the basis for the contention

The infiltration-, seepage-, thermohydrologic-, and the TSPA models for Yucca Mountain all use single (history independent) relative permeability and capillary pressure curves to model water flow through fractures. However, relative permeability curves are known to be hysteretic and even flow-rate dependent. Unstable regimes of fracture flow which cannot be modeled with the relative permeability approach were documented by Fourar, M., Bories, S., Lenormand, R. and Persoff, P. (1993) "Two-Phase Flow in Smooth and Rough Fractures: Measurement and Correlation by Porous-Medium and Pipe Flow Models" WATER RESOURCES RESEARCH, Vol. 29, No. 11 at 3699-3708) and Nicholl, M.J., and R.J. Glass (2005) "Infiltration into an Analog Fracture: Experimental Observations of Gravity-Driven Fingering," VADOSE ZONE JOURNAL, Vol. 4 at 1123-1151). The omission of these well-documented hysteretic properties by DOE implies that the aforementioned models can only be applied for monotonically decreasing or increasing saturations. This limitation is at odds with their application to both the heating (saturation decreasing) and cooling (saturation increasing) parts of the postulated repository thermal history. Furthermore, this shortcoming rules out their application to simulate wetting and drying cycles triggered by heavy thunderstorms as in 1984 and 2003 or to non-steady seepage or steam flow in the thermal phase of the repository.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings that NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(e) requires the performance assessment to provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment. Specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly

changed by their omission. Also, 10 C.F.R. § 63.114(c) requires the performance assessment to consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations of supporting scientific or factual materials

In SAR Subsection 2.3.3, the calibration of the capillary strength is discussed. Hysteresis of the relative permeability curves which is well documented process observed in field and in laboratory studies is excluded from DOE's dual continuum model. Thus, a single set of curves is used by DOE for imbibition and drainage cycles, although it is standard practice in groundwater hydrology or reservoir engineering to use separate pairs of experimentally determined relative permeability and capillary pressure curves for imbibition and drainage, respectively (*see, e.g.*, Dullien, F.A.L. (1992) "Porous Media: Fluid Transport and Pore Structure," 2d ed., ACADEMIC PRESS, San Diego, CA). Hysteretic behavior is ignored by DOE, and SAR Subsection 2.3.3.2.3 treats capillarity and permeability as effective parameters obtained by matching the model to "data that contain information about the seepage process."

This treatment implies that when physically realistic boundary conditions of episodic flow were introduced into the simulations, DOE's models would be used outside their range of calibration and therefore applicability. This fundamental shortcoming of the modeling strategy appears to be the underlying reason for why a large majority of the included FEPs concern steady-state and quasi-steady state behavior (i.e., gradually changing over thousands of years).

6. <u>Information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

Whereas DOE's infiltration-, seepage- (SAR Subsection 2.3.3), thermohydrologic- (SAR Subsection 2.3.3.3), and TSPA models (SAR Subsection 2.3.3.4) are designed for steady-state conditions, infiltration, thermally driven flow, and fracture seepage have all been documented to be episodic and this means that conditions at Yucca Mountain lie outside the range of applicability of DOE's models. This means that DOE models used do not comply with 10 C.F.R. § 63.114(e), which requires the performance assessment to provide the technical basis for either inclusion or exclusion of specific FEPs, such as hysteresis, in the performance assessment. Furthermore, there is a failure to comply with 10 C.F.R. § 63.114(c), which requires the performance assessment to consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository. Indeed, in this case, the alternative conceptual models that are available would often be preferred over the conceptual model adopted by DOE.

(f) Geochemistry of the Unsaturated Zone

NEV-SAFETY-55 - DATA FOR THE CHEMISTRY OF PORE WATERS IN THE TOPOPAH SPRINGS (TSw) FORMATION

1. A statement of the contention itself

Data for the chemical compositions (pH, alkalinity, nitrate) of pore waters in the Topopah Springs (TSw) rock formation, as used in SAR Subsection 2.3.5.3.2 and related subsections, are inadequate, because the data are incomplete and/or lack sufficient reliability.

2. A brief summary of the basis of the contention

The majority of 125 analyses of pore water samples have been screened out for various reasons; the remaining analyses have uncertainties and variabilities in pH values that are inconsistent with the assumption that pH is constrained by partial pressure of carbon dioxide $P(CO_2)$ and may also have microbial artifacts that would have decreased nitrate concentrations and thus biased the compositions of salts and deliquescent brines that will form during the thermal period.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(14) requires the SAR to include an evaluation of natural features of the geologic setting that are considered barriers important to waste isolation as required by 10 C.F.R. § 63.115. 10 C.F.R. § 63.115(b) (part of Subpart E) requires that the description of the capability of barriers offered by natural features should take account of uncertainties in characterizing and modeling their behavior. 10 C.F.R. § 63.21(c)(15) requires that the analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

This contention challenges the degree of certainty implied in the SAR about the chemical composition of present and future pore waters in the Topopah Springs Welded Tuff formation which would be the host formation for the disposal drifts. The chemical composition of water in the vicinity of the disposal drifts will influence the rates at which the disposal system components, i.e., drip shields and waste containers, will degrade and therefore the timing and rates of future radioactive waste releases. Moreover the uncertainty in pore water composition is propagated into the degree of uncertainty in the predictions by modeling of the compositions of salts and brines that will be formed in the drifts due to refluxing and deliquescence during the initial thermal period after waste emplacement.

In total, 125 analyses of TSw pore waters are available. *See* "Engineered Barrier System: Physical and Chemical Environment, ANL-EBS-MD-000033 REV06" (08/31/2007), LSN# DN2002452948 at § 6.6. After screening for "incomplete pore-water analyses and those not considered representative of current ambient conditions," *id*., Section 6.6.1, at 6-86, that total was reduced to 90. That number was further reduced to 34 after applying some criteria for identifying which samples had been affected by microbial processes during core storage. Best practice was evidently not being applied in allowing core samples to be stored and to have degraded in this way prior to extraction and analysis of pore waters. There must be doubt about the reliability of the chemical data for the selected 34 samples. This doubt applies especially to measured pH and alkalinity, i.e., bicarbonate anion, data because pH and alkalinity are particularly susceptible to microbial alteration as is admitted in DN2002452948, Section 6.6.3. On top of these uncertainties, "fully half of the analyses lack pH data and ten lack bicarbonate data," *id*. at 6-100, so that many of the pH values have been calculated from analyzed alkalinity by assuming a fixed value of 10^{-3} bars for $P(CO_2)$. These pH values will have additional uncertainties from the alkalinity data and the assumption of fixed $P(CO_2)$. Measured pH values vary from about 6.6 to 8.2 and $P(CO_2)$ calculated by assuming CO_2-bicarbonate equilibrium (only for samples where measured pH and alkalinity are available) is always higher than 10^{-3} bars. Therefore either pH calculated using $P(CO_2) = 10^{-3}$ bars is always too low, or the measured pH values are too high. These uncertainties are additional to those declared in paragraph 4.1.16 that were based on uncertainties in alkalinity data. The data for nitrate in pore waters probably have also been biased to low values by microbial degradation during core storage. This means that the chloride/nitrate ratios calculated with the EQ3/6 model for evaporation (*id*., Section 6.6.5) are likely to be too high. In summary, there are unquantifiable uncertainties in the measured and calculated chemical compositions of TSw pore waters and in the modeled compositions of evaporated brines and deliquescent salts. Thirty-four analyses is an insufficient number on which to understand the present-day variability and geochemical controls of pore water compositions, the likely future variability of compositions, and how the compositions of evaporative brines and deliquescent salts will be determined.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.5.3.2 and related subsections do not comply with 10 C.F.R. § 63.115(b), which requires that the description of the capability of barriers offered by natural features should take account of uncertainties in characterizing and modeling their behavior. This is because data for the chemical compositions (pH, alkalinity, nitrate) of pore waters in the Topopah Springs (TSw) rock formation are incomplete and/or lack sufficient reliability. Further 10 C.F.R. § 63.21(c)(15) requires that the analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions. The data for the chemical compositions (pH, alkalinity, nitrate) of pore waters in the Topopah Springs (TSw) rock formation do not comply with this requirement, again because the data are incomplete and/or lack sufficient reliability.

NEV-SAFETY-56 - GEOCHEMICAL INTERACTIONS AND EVOLUTION IN THE UNSATURATED ZONE, INCLUDING THERMO-CHEMICAL ALTERATION OF TSw HOST ROCK

1. A statement of the contention itself

Screening of FEPs (Features/Events/Processes) 2.2.08.03.0B and 2.2.10.09.0A "Geochemical interactions and evolution in the UZ" and "Thermo-chemical alteration of the TSw basal vitrophyre" from performance assessments in SAR Subsection 2.2.1.2 and related subsections and as specifically stated at SAR Table 2.2-1 at 2.2-143 and 2.2-145 is not justified.

2. A brief summary of the basis of the contention

Geochemical alteration of rocks in the unsaturated zone around and underlying deposition drifts will produce alteration minerals that will affect the retention and transport of radionuclides, therefore these FEPs should be considered in performance assessment in terms of alternative models for radionuclide transport.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those FEPs of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and the extent to which they affect waste isolation. 10 C.F.R. § 63.114(e) (part of Subpart E) requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Geochemical alteration of rock units in the unsaturated zone, namely the Topopah Springs Tuff (TSw) in the immediate vicinity of the deposition drifts and in the underlying unsaturated zone (UZ), will occur over the assessment timescale especially where affected by heating due to the waste. Alteration products will be calcium carbonate, iron oxide, zeolites and clay minerals. Radionuclides will be sorbed or co-precipitated with these alteration products and could subsequently be re-mobilized as "pulses" of radionuclides, if geochemical conditions in the UZ were to change. Possibilities of episodic release from secondary minerals have not been considered. These processes should be taken into account in performance assessment.

Thermo-chemical alteration of the TSw unit, specifically the basal vitrophyre lithology, is a specific case of such alteration because this unit would be subject to a long period of heating due to the emplaced waste. Being a volcanic glass, it is susceptible to thermal alteration to clays and zeolites. DOE’s justification for excluding this FEP is based on analogy with the extent of alteration caused by the period of natural hydrothermal heating following extrusion and deposition of these volcanic rocks. There is uncertainty and controversy over the duration of this past period of hydrothermal heating and alteration and also over whether the mechanism of heating was just conductive or also involved advection of heated water. *See* Dublyansky, Y. (2007), "Analysis of the Treatment, by the U.S. Department of Energy, of the FEP Hydrothermal Activity in the Yucca Mountain Performance Assessment," RISK ANALYSIS, Vol. 27 No. 6 at 1455-1468; and Dublyansky, Y. and Polyansky, O. (2007), "Search for the Cause-Effect Relationship Between Miocene Silicic Volcanism and Hydrothermal Activity in the Unsaturated Zone of Yucca Mountain, Nevada: Numerical Modeling Approach," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 112, B09201. In this context, DOE's justification is questionable and may not be valid.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

Screening of FEPs (Features/Events/Processes) 2.2.08.03.0B and 2.2.10.09.0A "Geochemical interactions and evolution in the UZ" and "Thermo-chemical alteration of the TSw basal vitrophyre" from performance assessments in SAR Subsection 2.2.1.2 and related subsections and as specifically stated at SAR Table 2.2-1 at 2.2-143 and 2.2-145 is not justified. Thus, these subsections do not comply with 10 C.F.R. § 63.114(e), which requires that any performance assessment must provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment, and specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-57 - DATA FOR NEAR-FIELD CHEMISTRY MODELS

1. <u>A statement of the contention itself</u>

SAR Subsection 2.3.5.3, and similar and related subsections, which state or assume that a limited number of pore water analyses are sufficient for the near-field chemistry model, is not justifiable and therefore fails to appropriately define the range of conditions in which corrosion can occur.

2. <u>A brief summary of the basis for the contention</u>

DOE assumes, incorrectly, that 34 pore water analyses from only three of the four members of the Topopah Spring Tuff, with limited geospatial sampling and no analyses of fracture flow water, is sufficient characterization for the near-field chemistry model, which provides the compositions of seepage water over time and temperature that will contact the in-drift EBS after it has cooled to below boiling temperatures.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of

the site and its effect on the safety and performance of the repository. 10 C.F.R. § 63.102(h) (part of Subpart E) requires a description of the natural barrier capabilities, including matrix diffusion in the unsaturated zone, so that the setting of the geologic repository is capable of contributing to the isolation of radioactive waste. 10 C.F.R. § 63.102(j) requires the performance assessment to represent a wide range of natural features, including potentially adverse effects of fracture flow. 10 C.F.R. § 63.114(a) (also part of Subpart E) requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) requires an identification of the natural features of the geologic setting that are considered barriers important to waste isolation, a description of their capabilities to isolate waste, and a technical basis for the description. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE has identified from less than a hundred pore water analyses in the Topopah Spring Tuff (TSw) only 34 analyses with the proper charge balance and lack of microbial activity that they consider sufficient to base the near-field chemistry model upon. The pore water analyses (*see* SAR Subsection 2.3.5.3.2.2.1 at 2.3.5-28) have been divided into four compositional groups (21, 7, 3, and 3 samples) and one group of three samples is from the same location (Alcove 5). Only three of the four members (Tptpul, Tptpmn, Tptpll, and Tptpln) of the TSw have been sampled. Yet, DOE has deemed this a sufficient number of samples to represent the entire TSw and with sufficient geospatial distribution in the TSw for the near-field chemistry model. In addition, DOE has not identified, or sampled, any natural fracture flow waters with which to validate their assumption that there is an equilibrium between fracture flow and matrix waters.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted.

The near-field chemistry model is discussed in SAR Subsection 2.3.5.3. The chemical analyses of pore waters are from a series of papers by Yang. *See* (1) Yang, I.C., Peterman, Z.E., and Schofield, K.M. (2003), "Chemical analyses of pore water from boreholes USW SD-6 and USW WT-24, Yucca Mountain, Nevada," J. CONTAMINANT HYDROLOGY, 1878:1-20, LSN# DN2000202392; (2) Yang, I.C., Yu, P., Rattray, G.W., Ferarese, J.S., and Ryan, J.N. (1998), "Hydrochemical investigations in characterizing the unsaturated zone at Yucca Mountain, Nevada, U.S. Geol. Survey," *Water-Resources Investigations Report* 98-4132, LSN# DEN000702996; and (3) Yang, I.C., Rattray, G.W., and Yu, P. (1996), "Interpretation of chemical and isotopic data from boreholes in the unsaturated zone at Yucca Mountain, Nevada. U.S. Geol. Survey," *Water-Resources Investigations Report* 96-4058, LSN# DEN000687467, with corrections at LSN# DEN000374732. This contention challenges SAR Subsection 2.3.5.3, and similar and related subsections, which state or assume that a limited number of pore water analyses are sufficient for the near-field chemistry model, and are not justifiable and therefore fail to appropriately define the range of conditions in which corrosion can occur, for the reasons given in paragraph 5 above. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(1)(ii), which requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, 10 C.F.R. § 63.102(h) (part of Subpart E), which requires a description of the natural barrier capabilities, including matrix diffusion in the unsaturated zone, 10 C.F.R. § 63.102(j), which requires the performance assessment to represent a wide range of natural features, including potentially adverse effects of fracture flow, 10 C.F.R. § 63.114(a), which requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment, and 10 C.F.R. § 63.115, which requires an identification of the natural features of the geologic setting that are considered barriers important to waste isolation, a description of their capabilities to isolate waste, and a technical basis for the description.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-58 - GROUNDWATER SAMPLES IN THE UNSATURATED ZONE SORPTION TESTS

1. A statement of the contention itself

SAR Subsection 2.3.8.3.1, and similar and related subsections, assume without validation that two groundwater compositions (from the saturated zone) are representative and useful for experimentation to describe radionuclide sorption in the unsaturated zone.

2. A brief summary of the basis for the contention

DOE assumes without proof that two saturated zone groundwater compositions, J-13 well water and UE-25#p1 (a deep carbonate well water), are representative of unsaturated zone waters for use in laboratory sorption experiments for the purposes of determining the ranges of radionuclide retardation coefficients, K_ds.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

In SAR Subsection 2.3.8.3.1, DOE assumes without any comparisons to analyses of fracture water (none measured directly, *see* SAR at 2.3.5-30), unsaturated matrix pore waters (four groups, Near-Field Chemistry model, SAR Subsection 2.3.5.3 at 2.3.5-29), or thermally evolved seepage evaporation waters (In Drift Chemical Environment Model, SAR Subsection 2.3.5.5), that two saturated zone groundwater samples, J-13 well water and a deep carbonate saturated zone well sample, UE-25#p1, are representative for use in radionuclide sorption experiments that determine the ranges of the radionuclide sorption coefficient, K_d. It is unreasonable and unjustified for DOE to say that these two groundwater samples are representative of all unsaturated zone waters. The radionuclide retardation coefficients for the various radionuclides of interest are functions not only of the solids (rock samples) used in the sorption experiments, but also of the chemistry of the water samples. *See* Zhu (2003), "A case against Kd-based transport models: natural attenuation at a mill tailings site," COMPUTERS & GEOSCIENCES, Vol. 29, No. 3 at 351-359.

DOE uses two groundwater compositions (from the saturated zone) in radionuclide sorption experiments and then assumes without proof that these results are representative and applicable to sorption and retardation in the unsaturated zone between the repository level and the water table. There are no analyzed samples of flowing fracture water for comparison purposes to support this assumption, nor is there a comparison of the two groundwater samples with analyzed samples of matrix pore waters (*see* SAR Subsection 2.3.8.3.1). Without any proof of the relevance of the groundwater samples to any groundwater present in the unsaturated zone, the DOE assumption is not justified, and the applicability of the sorption experiments to the unsaturated zone cannot be supported.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.8.3.1, and similar and related sections, that assume without validation that two groundwater compositions (from the saturated zone) are representative and useful for experimentation to describe radionuclide sorption in the unsaturated zone. Thus, these subsections do not comply with 10 C.F.R. § 63.21(c)(1)(ii), which requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-59 - GROUNDWATER COMPOSITIONS ASSUMED

1. A statement of the contention itself

SAR Subsection 2.3.8.3.1 and similar subsections, which state that only two natural water compositions bound the range of water compositions expected in the unsaturated zone for the purposes of sorption and radionuclide transport, is illogical and impossible for a multi-component aqueous system and means that the sorption and radionuclide transport calculations cannot be relied upon.

2. A brief summary of the basis for the contention

DOE assumes that it is possible to bound a multi-component aqueous system, consisting of major cation components (Na^+, K^+, Ca^{2+}, Mg^{2+}) and anionic components (HCO_3^-, SO_4^{2-}, Cl^-, NO_3^-, F^-) with only two natural water samples that are taken to be representative of percolation waters expected in the unsaturated zone.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of

the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(a) (also part of Subpart E) requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment. In addition, 10 C.F.R. § 63.114(b) (also part of Subpart E) requires any performance assessment used to demonstrate compliance with 10 C.F.R. § 63.113 to account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In analytical chemistry, when one is attempting to determine the concentration of one species or component (such as a cation or metal), a calibration line (or curve) is constructed first by measuring the concentration of (at least) two solutions with known concentrations of the species of interest and generally with one concentration that is lower and the other that is higher than that of the unknown solution, thereby bracketing, or "bounding," the unknown solution.

This technique assumes that all other variables (the matrix) in the two known solutions are equal and similar to that of the unknown solution. When extrapolating this type of technique to multiple variables (major cationic and anionic species or components) one might assume that two solutions are necessary for each variable. The DOE sorption experiments are more complex that this slightly simpler analogy, because the sorption of a number of individual radionuclides is being determined on the same rock type. However, DOE assumes that only two solutions in total are required, perhaps because otherwise the matrix of necessary experiments becomes incredibly large. In addition, the two natural water compositions chosen are not specific for transport and sorption in the unsaturated zone as they are groundwater compositions from the saturated zone. Before 1990, when sorption experiments began, there were no site-specific analyses of fracture or pore waters from the unsaturated zone. *See* Harrar, J.E. (1990), *et al.*, "Report of the Committee to Review the Use of J-13 Well Water in Nevada Nuclear Waste Storage Investigations, Lawrence Livermore National Laboratory," UCID-21867, LSN# DN2001940431 at 6.1 to 6.2. Furthermore, DOE has given no consideration to the compositions of seepage waters (*see* SAR Subsection 2.3.5) that may develop over time as the thermal history of the repository evolves. Thus, the water compositions adopted do not provide an appropriate basis for the evaluation of parameters characterizing radionuclide sorption and transport in the unsaturated zone, with significant implications for the fluxes of radionuclides released and doses to the reasonably maximally exposed individual.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges a DOE assumption from SAR Subsection 2.3.8.3.1 at 2.3.8-19 that it is possible to "bound" multi-component aqueous solution compositions expected in the unsaturated zone with only two natural groundwater compositions. In consequence, it is argued that the water compositions adopted do not provide an appropriate basis for the evaluation of parameters characterizing radionuclide sorption and transport in the unsaturated zone. Thus, there is a failure to comply with 10 C.F.R. § 63.114(a) because appropriate data related to geology, hydrology and geochemistry have not been used to define parameters and conceptual models used in the performance assessment. In addition, there is a failure to comply with 10 C.F.R. § 63.114(b) because estimates of sorption made using these groundwater compositions are not adequate to account for uncertainties and variabilities in parameter values or to provide the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-60 - EMPIRICAL SITE-SPECIFIC DATA AND THE NEAR-FIELD CHEMISTRY MODEL

1. A statement of the contention itself

DOE's near-field chemistry model is not site specific and therefore not valid for Ti-7 and C-22 corrosion studies because the unsaturated zone hydrogeochemical characterization pore-water data are not satisfactory for determining the environment in which in-drift geochemical reactions will occur.

2. A brief summary of the basis for the contention

DOE's unsaturated zone water characterization is invalid because of factors that include bacterial/fungal contamination (SAR Subsection 2.3.5.3.3.2.1), grossly incomplete pore-water analyses (SAR Subsection 2.3.5.3.3.2.1), unjustifiable screening procedures (SAR Subsection 2.3.5.3.2.2.1), and most importantly, the use of pore-water instead of fracture flow water data. Therefore, hydrogeochemical characterization is unreliable and uncertain and not specifically focused on near-field unsaturated zone water that could reasonably come into contact with in-drift EBS materials; consequently, DOE's bin pore-waters (SAR Table 2.3.5-5) are not representative of in-drift percolation and therefore the DOE model derived from these data is inaccurate, not site specific and not valid for corrosion studies relating to Ti-7 and C-22.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses

barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations to support scientific or factual materials

There are two paramount issues that come into play with regards to the utility of the DOE bin pore-waters for use in corrosion studies:

Issue 1: Unsaturated zone pore-waters cannot normally be equated with fracture flow waters; however, DOE treats unsaturated zone pore-water as being geochemically equivalent to unsaturated zone fracture flow water.

SAR Subsection 2.3.5.3.2.2.1, at 2.3.5-30 states:

> The starting waters for the near-field chemistry model are sampled from the available matrix pore-water analyses for the repository host units of the Topopah Spring Tuff. Using multiple lines of evidence, fracture water chemistries are shown to be similar to the matrix pore-water, although no fracture water compositions have been measured directly. (Emphasis added.)

DOE's premise for equating the hydrogeochemistry of pore-water to fracture flow water involves two lines of reasoning, each of which is addressed separately below.

DOE Concept 1: "Equilibration of matrix and fracture water is rapid relative to downward transport throughout much of the host rock mass." SAR Subsection 2.3.5.3.2.2.1, at 2.3.5-30.

This premise is based upon a DOE plug flow model with averaged rock properties, assuming ambient saturation and is a simplification that does not consider different rock units or actual matrix and fracture saturations. Finite element heat and mass transfer code (FEHM) modeling provided the following rational: "Because the FEHM calculations so closely match the plug flow approximation and because of the reciprocity exhibited when the particles are injected into the fracture or matrix, fracture-matrix exchange must be rapid relative to downward transport though the Topopah Spring Tuff." SAR Subsection 2.3.5.3.3.2.7 at 2.3.5-44.

However, DOE's observations may incorrectly distinguish matrix (pore and micro-fracture) from small and large fracture flow. There are no data presented to indicate that matrix as defined in FEHM equates to matrix as defined with respect to pore-water chemistry. From a geochemical point of view, it is most doubtful that fracture flow water in fast path transport will come into equilibrium with the wall rock of the fractures in welded tuffs. There is just not sufficient time for this to happen. However, it is likely that pore-water will be in a meta-stable equilibrium state with the matrix rock because of the long time of rock-water interaction, especially in tight matrix pores and micro-fractures. In some instances, one might even expect that the matrix pore water is connate. A higher TDS is expected for pore-water that has been trapped inside matrix pore and micro-fracture structures than for fracture flow unsaturated zone water that is in fast path or moderately fast path gravity driven transport. A large (cation and anion) inoculation in surface water takes place at the ground surface and within the soil zone. These portions of the unsaturated zone contain large particle surface areas, cation exchange clays, plant root control on soil gas, evaporative salts, and organic complexes that react with surface water to provide an initial hydrogeochemical signal. The basic hydrogeochemical signal is therefore set upon infiltration and is only modified by dissolution and evaporation along the fracture flow transport pathways until it joins the mixing waters in the saturated zone. If a portion of the downward transporting water diffuses into the matrix it can acquire a strong geochemical signal from the host rock matrix and this signal is certainly dependent on its residence time for rock-water interaction.

DOE relies upon matrix diffusion as a mechanism of radionuclide retardation in the unsaturated zone. DOE specifically supports the concept of slow matrix diffusion when it desires to take credit for radionuclide retardation. Yet, when DOE has not adequately collected appropriate unsaturated zone water to characterize the near-field, it suggests that the slowly diffusive matrix pore-water is chemically the same as fast flowing fracture flow unsaturated zone water. DOE's arguments are inconsistent.

DOE Concept 2: "Strontium isotopic composition of fracture-lining calcite from the TSw unit also supports rapid matrix-fracture equilibration" based upon microstratigraphy of the calcite strontium isotopic ratios. "Uranium-series isotopic data also indicate fracture-matrix water equilibrium." Whole-rock deficiencies are similar between fractured tuff samples from the Sundance and Drill Hole Wash Fault zones and the unfractured ECRB Cross-Drift tuff. "Uranium isotopic data from fracture minerals also show evidence of matrix-fracture interactions" because fracture minerals such as opal and calcite show long-term continuous growth from water that does not have a surface signal. SAR Subsection 2.3.5.3.2.2.1 at 2.3.5-30 and 31.

Fracture flow water that diffuses into the matrix does so by slowing down with depth of penetration, which is the quadratic diffusive process. All of the isotopic data obtained by DOE (strontium and uranium) are evidence of fracture path transport, not matrix pore-water diffusion. DOE data obtained does not at all support a conclusion that there was rapid matrix-fracture exchange. The lithophysae studied were in fracture continuity. There was no matrix pore-space geochemically studied using strontium and uranium by DOE. One cannot take geochemical data from large lithophysae and extrapolate those data to microscopic pore-structures and micro-fractures that receive unsaturated zone water by diffusion. The pore-water chemistry obtained by DOE is not from lithophysae structures rather it is from tight matrix diffusive structures. Consequently, the isotope data is representative of fracture flow conditions and the pore-water hydrogeochemistry utilized by DOE is from tight matrix pores. The two do not equate; they are not the same. Calcite formed along fracture wall surfaces is a function of the hydrogeochemistry and evaporation along the fracture system, not the welded tuff matrix. The correlative argument that unsaturated zone pore-water hydrogeochemistry is similar to fracture flow water is incorrect and misleading. There is no way that DOE pore-waters obtained represent fracture flow water that can percolate into the emplacement drifts.

Issue 2: <u>Quality (contamination and incomplete analyses) of DOE unsaturated zone pore-water data and unjustifiable screening procedures.</u>

Even in the case of the pore-water, the 34 analyses that are relied upon by DOE are limited in number, unrepresentative spatially, inappropriately screened and may have been minimally affected by bacterial action.

"Engineered Barrier System: Physical and Chemical Environment ANL-EBS-MD-000033 REV 06B" (08/31/2007), LSN# DN2002452948, Section 4.1.1 at 4-5, states that over 90 pore-water analyses were obtained, of which many were determined to have been compromised by bacterial activity during core storage prior to the collection of the water samples for analysis. DOE found 34 samples of the over 90 total samples to be "*minimally affected*" by microbial activity. The screening procedures used to obtain the 34 analyses are not without controversy. (*See, e.g.*, SAR Subsection 2.3.5.3.2.2.1 at 2.3.5-28, which states that "two screening criteria, based on the charge balance (+/-10% was considered acceptable) and on the calculated pH upon equilibration, proved sufficient to screen out affected waters, reducing the total number of analyses to 34.") DOE grouped these analyses (below) into 4 chemical pseudo-cluster groups and they determined a water composition for each group based upon the centroid of each pseudo-cluster. SAR Subsection 2.3.5.3.3.2.1 at 2.3.5-37 states that the above four types of pore-water "are assumed to adequately represent the actual range of pore-water compositions in the natural system." These four groups of unsaturated zone water (*see* SAR Subsection 2.3.5.3.2.2.1) "compositions are used as starting water compositions for the near-field chemistry model, which provides potential seepage water compositions to the in-drift chemical environment models." SAR Subsection 2.3.5.3.3.2.1 at 2.3.5-29. Each group of waters is given equal weight in the model.

DOE Bin Centroid Water Type Chemistry (all data in mg/L)
(LSN# DN2002452948)

Type	**Ph**	**Na**	**K**	**Mg**	**Ca**	**Cl**	**SO_4**	**HCO_3**	**NO_3**	**F**	**SiO_2**
1	8.2	59	4.8	0.70	19	23	16	142	16	2.2	4.2
2	7.7	45	14.4	7.9	62	67	82	126	44	1.4	52
3	8.31	62	9	17.4	97	123	120	ND	10	0.76	75
4	ND	123	13.8	16.7	59.9	146	126	149	57.4	1.3	ND

For type-3 unsaturated zone water, DOE does not have a complete analysis (bicarbonate is missing), and for type-4 unsaturated zone water both pH and SiO_2 values are missing. Only 50% of the four unsaturated zone water types have complete chemical analyses (all or some of these analyses may be compromised by bacterial contamination as DOE states that they are "*minimally affected*"). SAR Subsection 2.3.5.3.2.2.1 at 2.3.5-27 states: "waters missing pH data, bicarbonate concentrations, or silica concentrations were included in the analysis because values for these parameters can be derived when the samples are pre-equilibrated for use in the near-field chemistry model (SNL 2007n, Section 6.6)." Group Three only has three samples in it – all from the same location: Alcove 5, HD-PERM-3, interval 34.8-35.1 – and Group Four has three samples; consequently, over 78% of the analyses used by DOE fall into only two of their group types (Groups 1 and 2).

DOE has not justified the premise that these four types of unsaturated zone water adequately represent the pore-water unsaturated zone environment. For example, there are no low bicarbonate waters represented in the set of DOE unsaturated zone waters, yet such water compositions are clearly represented in the DST Borehole water samples (such as BH60-3-

0504396, *see* "Thermal Testing Measurements Report, ANL-NBS-HS-000041 REV 00" (09/26/2002), LSN# DN2002296975, Table 6.3.4.1-2 at T6.3-46-51). Many of the DST borehole water samples have phosphate concentrations above background, yet no phosphate data are presented for the bin pore-waters. Phosphate is, of course, commonly metabolized during bacterial/fungal activity so that if the pore-water samples were not contaminated by bacterial activity there might be detectable phosphate concentrations present. This would not only be important in the screening procedure, but would also be important in determining future potential bacterial action within the unsaturated zone (*e.g.*, MIC). The absence of reported phosphate analyses clearly undermines the utility of the pore-water chemistry with respect to EBS corrosion concerns. The quality of the DOE reported pore-water is below standard acceptable practices in hydrology and certainly below competent practices when these analyses are so important with respect to determining the lifetime of critical EBS materials such as C-22. There is no reason to presume that the values reported are actually representative of the full range or common pore-waters in the unsaturated zone as stipulated by DOE. The DOE qualified samples are too few and are unrepresentative in their spatial distribution.

Some of the analyses are plagued by poor charge balances and exhibit a consistent anion deficiency. DOE attributes the analyses with poor charge balance to organic acids such as propionic acid derived from microbial fermentation. It is unknown if all the organic acids are a function of microbial metabolism in the cores – a clear function of contamination, or are actually naturally common (derived from surface or subsurface biologic activity) to the pore-waters in the tuff, or some combination thereof. Even so, it is also clear that DOE has not provided complete analyses for the pore-waters studied, so that the charge balance calculations are grossly incomplete.

DOE uses trace elements strontium and manganese to discriminate between the screened-in and screened-out (elevated values) pore-water. The geochemical reactions responsible for the correlation between bacterial/fungal activity and elevated $Sr_{aqueous}$ and $Mn_{aqueous}$ concentrations have not been derived by laboratory testing by DOE. There are no empirical studies provided to suggest that these reactions are valid. It appears only from the data presented that the DOE excluded pore-waters that have "elevated values" for strontium and manganese. The screening cut-off points seem to be arbitrary, and if not, they are not based upon either empirical evidence from Yucca Mountain or from laboratory experimentation.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsections 2.3.5.3.2.2.1 and 2.3.5.3.3.2.1 provide pore-water analyses that are said to correlate with fracture flow unsaturated zone water in the Yucca Mountain near-field environments. Fracture flow waters are expected to percolate into the in-drift and react with the C-22 outer canister engineered barrier. DOE fails to provide adequate evidence to show that the pore-waters that are of questionable quality are the same as unsaturated zone fracture flow water that can come into contact with the waste canisters. Further, DOE admits to not collecting unsaturated zone fracture flow water. Consequently, there are no reliable hydrogeochemical data (not even one sample) for the in-drift seepage and for reactions in the waste emplacement environment. The near-field chemistry model (SAR Subsection 2.3.5.3), along with the in-drift chemical environment characterization (SAR Subsection 2.3.5), are based upon data which are not repository site specific or reasonably sound from a quality perspective. This means that models of corrosion and radionuclide release used for performance assessment purposes are unsound and cannot be used to evaluate the degradation, deterioration, or alteration processes of engineered barriers. In consequence, these subsections do not comply with 10 C.F.R. §

63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must evaluate the degradation, deterioration, or alteration processes of engineered barriers in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

(g) Seepage into the Emplacement Drifts

NEV-SAFETY-61 - AMBIENT SEEPAGE INTO EMPLACEMENT DRIFTS

1. A statement of the contention itself

SAR Section 2.1 and Subsection 2.3.3.2, and similar and related subsections, which state or assume that post-closure ambient seepage of water into emplacement drifts will be reduced by capillary forces, is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability, and capillary strength of fractured rock) and geometry of the emplacement drifts, and thus completely fails to consider engineered ground support items (*e.g.*, the Bernold-type perforated stainless steel liners) that are deemed necessary for the safety of pre-closure operations.

2. A brief summary of the basis for the contention

DOE's analysis of the post-closure flow diversion of unsaturated zone percolation around the emplacement drifts and water seepage into the drifts depends on a conceptual model and analysis of the drifts that considers only natural rock and flow properties (and geometry of the mined opening), and thus totally fails to consider an engineered ground support item (i.e., perforated stainless steel liners), which if considered will reduce if not almost completely eliminate any capillary barriers to water flow into the waste-containing drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Diversion of the flow of percolation waters around the emplacement drifts is dependent on the amount of percolation flow, the rock permeability, and the capillary strength. As reflected in SAR Section 2.1 and Subsection 2.3.3.2, DOE considers the emplacement drift to act essentially as a capillary barrier, which DOE considered as an increase of porosity and permeability in the direction of flow (in this case gravity) that causes fluid to flow in other directions. The rock permeability, mainly fracture permeability, is increased slightly around the mined opening of the emplacement drift due to excavation disturbance compared with the undisturbed rock, and the emplacement drift acts as a very large pore. However, DOE has ignored the installation of an impervious barrier (except for the perforations, or elongated slots or holes with rounded ends) in the form of the Bernold-type perforated stainless steel liners. These liners will be installed against the upper surface of the emplacement drift (240° in cross section), will be in contact with the rock surface, and are essentially impermeable (except for the rather large perforations, compared with the size of fracture apertures in the rock or rock pores). The effect of the liners will be to facilitate seepage flow onto the liners, which then increases the possibility of flow or drips through the perforations onto the EBS. An analogy may be useful here: consider an old canvas tent in a rainstorm. The interior of the tent represents the mined opening of the emplacement drift and the canvas represents the drift wall. Barring any holes in the tent, the rain will hit the canvas and flow down the sides leaving the interior dry. However, if someone inside the tent touches the canvas, then a leak or drip develops. The touching of the canvas is analogous to the stainless steel Bernold-type perforated liner touching the drift wall – drips will develop.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Section 2.1 and Subsection 2.3.3.2, and similar and related subsections, which state or assume that post-closure ambient seepage of water into emplacement drifts will be reduced by capillary forces, but this is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability, and capillary strength of fractured rock) and geometry of the emplacement drifts, and thus completely fails to consider an engineered ground support items (*e.g.*, the Bernold-type perforated stainless steel liners) that are deemed necessary for the safety of pre-closure operations. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada’s contentions.

NEV-SAFETY-62 - THERMAL SEEPAGE INTO EMPLACEMENT DRIFTS

1. A statement of the contention itself

SAR Section 2.1 and Subsection 2.3.3.1, and similar and related subsections, which state or assume that post-closure thermal seepage of water into emplacement drifts will be reduced by capillary forces, is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability and porosity, capillary strength of fractured rock), temperature increases due to waste decay, and geometry of the emplacement drifts, and thus completely fails to consider engineered ground support items such as Bernold-type perforated stainless steel liners, which are deemed necessary for the safety of pre-closure operations.

2. A brief summary of the basis for the contention

DOE's analysis of the post-closure flow diversion of unsaturated zone percolation during the thermal period around the emplacement drifts and water seepage into the drifts depends on a conceptual model and analysis of the drifts that considers only natural rock and flow properties (and geometry of the mined opening), and thus totally fails to consider an engineered ground support item (i.e., perforated stainless steel liners), which if considered will reduce if not almost completely eliminate any capillary barriers to water flow into the waste-containing drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Diversion of the flow of percolation waters around the emplacement drifts is dependent on the amount of percolation flow, the rock permeability, and the capillary strength. As reflected in SAR Subsection 2.3.3.1 at 2.3.3-4, DOE considers the emplacement drift to act essentially as a capillary barrier. A capillary barrier can be considered as an increase of porosity and permeability in the direction of flow (in this case gravity) that causes fluid to flow in other directions. The rock permeability, mainly fracture permeability, is increased slightly around the mined opening of the emplacement drift due to excavation disturbance compared to the undisturbed rock, and the emplacement drift acts as a very large pore. However, DOE has ignored the installation of an impervious barrier (except for the perforations, or elongated slots or holes with rounded ends) in the form of the Bernold-type perforated stainless steel liners. These liners will be installed against the upper surface of the emplacement drift (240° in cross section), will be in contact with the rock surface, and are essentially impermeable (except for the rather large perforations, compared to the size of fracture apertures in the rock or rock pores). The effect of the liners will be to facilitate seepage flow onto the liners, which then increases the possibility of flow or drips through the perforations onto the EBS. An analogy may be useful here: consider an old canvas tent in a rainstorm. The interior of the tent represents the mined opening of the emplacement drift and the canvas represents the drift wall. Barring any holes in the tent, the rain (analogous to percolation) will hit the canvas and flow down the sides leaving the interior dry. However, if someone or something inside the tent touches the canvas, then a leak or drip develops. The touching of the canvas is analogous to the stainless steel Bernold-type perforated liner touching the drift wall – drips will develop.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Section 2.1 and Subsection 2.3.3.1, and similar and related subsections, which state or assume that post-closure thermal seepage of water into emplacement drifts will be reduced by capillary forces, because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability and porosity, capillary strength of fractured rock), temperature increases due to waste decay, and geometry of the emplacement drifts, and thus completely fails to consider engineered ground support items such as Bernold-type perforated stainless steel liners, which are deemed necessary for the safety of pre-closure operations. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that

are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-63 - EFFECT OF ROCK BOLTS ON AMBIENT SEEPAGE

1. A statement of the contention itself

SAR Section 2.1 and Subsection 2.3.3.2 of the SAR, and similar and related subsections, which state or assume that post-closure ambient seepage of water into emplacement drifts will be reduced by capillary forces, is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability and porosity, capillary strength of fractured rock) and geometry of the emplacement drifts, and thus fails to adequately consider an engineered ground support item, i.e., the hundreds of thousands of un-grouted super Swellex-type stainless steel rock bolts, which is deemed necessary for the safety of pre-closure operations.

2. A brief summary of the basis for the contention

DOE's analysis of the post-closure flow diversion of unsaturated zone ambient percolation around the emplacement drifts and water seepage into the drifts depends on a conceptual model and analysis of the drifts that considers only natural rock and flow properties (and geometry of the mined opening), and thus provides an inadequate consideration of an engineered ground support item, the hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts, which may reduce capillary barriers to ambient water flow diversion around the waste-containing drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Diversion of the ambient flow of percolation waters around the emplacement drifts is dependent on the amount of percolation flow, the rock permeability, and the capillary strength. As reflected in the SAR Subsection 2.3.3.1 at 2.3.3-4, DOE considers the emplacement drift to act essentially as a capillary barrier. There are 10 rock bolts in a vertical cross section of any emplacement drift, spaced at a distance of 1.25 m and penetrating into the drift wall a distance of 3 m. The vertical sections with rock bolts are spaced 1.25 m apart horizontally to yield a 1.25 m square grid pattern of rock bolts, which implies that there are hundreds of thousands of rock bolts along the drifts. However, only 6 bolts are inclined downward towards the emplacement drift, the others are either sub-horizontal (2) or inclined upwards towards the drift (2). The rock bolt hole is 3 inches in diameter and the Swellex-type rock bolt is expanded to snugly fill this hole by a few hundred pounds of water pressure; although there is a small section of the rock diameter that is not in contact with the metal as the maximum expansive bolt diameter must be greater than 3 inches to ensure a snug fit and that the bolt does not rupture. This small, inwardly curved portion of the rock bolt diameter that is not in intimate contact with the rock wall provides an opening that may act as a channel or drain for ambient seepage to enter the emplacement drift. Since these drilled holes are not open (unfilled) to act as potential capillary barriers, but contain an impervious metallic layer that is in tight against the rock, the rock bolts will facilitate liquid flow towards the emplacement drift, at least for those that are downward facing. With the rock bolts extending out 3 m from the drift wall into the wall rock, there is larger capture volume for seepage waters than without them.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Section 2.1 and Subsection 2.3.3.2, and similar and related subsections, which state or assume that post-closure ambient seepage of water into emplacement drifts will be reduced by capillary forces, but this is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability and porosity, capillary strength of fractured rock) and geometry of the emplacement drifts, and thus fails to adequately consider an engineered ground support item, i.e., the hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform.

Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-64 - EFFECT OF ROCK BOLTS ON THERMAL SEEPAGE

1. A statement of the contention itself

SAR Section 2.1 and Subsection 2.3.3.2, and similar and related subsections, which state or assume that post-closure thermal seepage of water into emplacement drifts will be reduced by capillary forces, is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability and porosity, capillary strength of fractured rock) and geometry of the emplacement drifts, and fails to adequately consider an engineered ground support item, i.e., the hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts, which is deemed necessary for the safety of pre-closure operations.

2. A brief summary of the basis for the contention

DOE's analysis of the post-closure flow diversion of unsaturated zone thermal percolation around the emplacement drifts and water seepage into the drifts depends on a conceptual model and analysis of the drifts that considers only natural rock and flow properties (and geometry of the mined opening), and that provides an inadequate consideration of an engineered ground support item, the hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts, which may reduce capillary barriers to ambient water flow diversion around the waste-containing drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Diversion of the ambient flow of percolation waters around the emplacement drifts is dependent on the amount of percolation flow, the rock permeability, and the capillary strength. The emplacement drift is stated by DOE in SAR Subsection 2.3.3.1 at 2.3.3-5 to act essentially as a capillary barrier. There are 10 rock bolts in a vertical cross section of any emplacement drift, spaced at a distance of 1.25 m and penetrating into the drift wall a distance of 3 m. The vertical sections with rock bolts are spaced 1.25 m apart horizontally to yield a 1.25 m square grid pattern of rock bolts, which means that there are hundreds of thousands of rock bolts along the drifts. However, only 6 are inclined downward towards the emplacement drift, the others are either sub-horizontal (2) or inclined upwards towards the drift (2). The rock bolt hole is 3 inches in diameter and the Swellex-type rock bolt is expanded to snugly fill this hole by a few hundred pounds of water pressure; although there is a section of the diameter that is not in contact with the metal as the maximum expansive bolt diameter must be greater than 3 inches to ensure a snug fit and that the bolt does not rupture. This small, inwardly curved portion of the rock bolt diameter that is not in intimate contact with the rock wall provides an opening that may act as a channel or drain for ambient seepage to enter the emplacement drift. Since these drilled holes are not open (unfilled) to act as potential capillary barriers, but contain an impervious metallic layer that is in tight against the rock, the rock bolts will facilitate liquid flow towards the emplacement drift, at least for those that are downward facing. With the rock bolts extending out 3 m from the drift wall into the wall rock, there is larger capture volume for seepage waters than without them.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Section 2.1 and Subsection 2.3.3.2, and similar and related subsections, which state or assume that post-closure thermal seepage of water into emplacement drifts will be reduced by capillary forces, but this is incorrect because the analysis only considers drift-wall rock properties (*e.g.*, flow characteristics in the unsaturated zone, permeability and porosity, capillary strength of fractured rock) and geometry of the emplacement drifts, and fails to adequately consider an engineered ground support item, i.e., the hundreds of thousands of ungrouted super Swellex-type stainless steel rock bolts, which is deemed necessary for the safety of pre-closure operations. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that

are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-65 - STRUCTURAL CONTROL OF SEEPAGE IN THE EMPLACEMENT DRIFT

1. A statement of the contention itself

SAR Subsection 2.3.2 and similar subsections, which describe unsaturated zone flow, fail to recognize that the Yucca Mountain fracture geometry controls the spatial distribution of seepage into the in-drift environment, which affects water delivery to the drip shield and waste package.

2. A brief summary of the basis for the contention

Yucca Mountain faults occur in patterned stress fields and function as the transport pathways in the unsaturated zone controlling the geometry of seepage and therefore determining the large-scale spatial geometry of corrosion.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and

Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Caves and old mine tunnels that are fed by fracture flow dripping commonly develop a stalactite, stalagmite and column pattern which follows the fault pattern of the host rock. In those occurrences, stalactites are spaced along the intersecting ceiling fractures according to aperture conductivity. The ceilings of those caves have fault/fracture patterns that usually develop as an expression of joint sets and are therefore associated with tensile displacements. Shear fractures also exist that develop within the local stress field and their geometry is commonly different from the tensile displacements. Tensile fractures form parallel and orthogonal to the greatest principal stress; whereas, shear fractures dominantly occur at 45 degrees minus the angle of rock friction to the greatest principal stress in dihedral patterns.

Fractures and faults form conduits in Yucca Mountain tuffs and are the principal modes of unsaturated zone water transport. Fracture and fault spacing and spatial geometry determine the points of intersection with the Yucca Mountain emplacement drifts. Seepage into the emplacement drifts is therefore not a haphazard process. The points of dripping ingress are controlled by fracture-fault spatial geometry and form alignments along the ceiling and wall surfaces. Repository heating will affect the aperture of faults and fractures, but not the fault-fracture net spatial geometry.

DOE will presumably map the ceiling and wall surfaces of the mined tunnels and drifts during the construction process. As a consequence, the distribution of major fractures and most faults should be known. Yet, no consideration is given in the License Application with respect to the correlation between seepage and fracture-fault spatial patterning. Conductive fractures and faults above drip shield and waste canisters will provide seepage drip alignments that result in patterned wetting of the EBS surfaces. This patterning may have very significant controls on the focusing of corrosion on these EBS materials and consequently these data would be of primary importance with respect to radionuclide containment. DOE gives no consideration to the potential implications of patterned corrosion on drip shield and waste package failure, and on subsequent radionuclide transport. Nor is consideration given as to how data obtained from mapping of the emplacement drifts will affect the waste package and drip shield emplacement strategy.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsection 2.3.2 and similar subsections, which describe unsaturated zone flow, fail to recognize that Yucca Mountain fracture geometry controls spatial distribution of seepage in the in-drift environment, which affects water delivery to the drip shield and waste package. These processes in part control the distribution of corrosion on the EBS surfaces. As consideration of the control of seepage and hence of EBS degradation exerted by fracture geometry is missing from the license application, it does not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must evaluate in detail the degradation, deterioration, or alteration processes of engineered barriers if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

NEV-SAFETY-66 - ATTENUATION OF SEEPAGE INTO NATURALLY FRACTURED DRIFT WALLS

1. A statement of the contention itself

SAR Subsection 2.3.3 and related subsections argue for a flow diversion around the repository drifts due to capillary forces, but in the presence of drift-wall fractures this is not a valid assumption which implies that more water will enter the emplacement drifts than is asserted by DOE.

2. A brief summary of the basis for the contention

DOE inappropriately argues that a capillary process analogous to the capillary end effect will divert water around the emplacement drifts, but considerations of variations in fracture aperture, the imbibing of fluids into fractures, and mechanisms akin to gas-oil gravity drainage all demonstrate that alternative conceptual models are readily justified that may result in water preferentially entering the emplacement drifts rather than being diverted around them.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings that NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(e) requires the performance assessment to provide the technical basis for either inclusion or exclusion of specific FEPs in the performance assessment. Specific FEPs must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Also, 10 C.F.R. § 63.114(c) requires the performance assessment to consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository.

5. <u>A concise statement of the facts or expert opinions supporting the contention along with appropriate citations of supporting scientific or factual materials</u>

SAR Subsection 2.3.3 treats the drift wall as a capillary barrier to the flow of water into the repository drifts, including this conceptual model into its TSPA abstraction of engineered barrier systems in SAR Subsection 2.3.3.4. DOE thus argues that a capillary process similar to that producing the "capillary end effect" (*cf.*, Richardson, J.G., Kerver, J.K., Hafford, J.A., and Osoba, J.S. (1952) "Laboratory Determination of Relative Permeability," TRANS. AM. INST. MIN. ENG., Vol. 195 at 187) diverts flow around repository drifts reducing seepage into them. This treatment, however, is an unsubstantiated extrapolation from granular porous media (PM) behavior as seen in cm-scale experiments to heterogeneous volcanoclastics intersected by meter-scale subvertical fractures with variable aperture. By contrast to the homogeneous PM, in the fractured tuff, water can imbibe into narrow aperture segments without overcoming an entry pressure threshold. After its entry into the fracture, the water is subjected to a new balance between gravitational and capillary forces. Where fracture aperture increases downward, capillary and gravitational pressure gradients are aligned, so driving the fluid toward the drift roof. It follows that where gradual aperture variations in the fractures exist, the end-effect argument does not apply. For plausible aperture values, the vertical extent that water saturated fracture segments have to exceed before they become gravitationally unstable is as small as a few tens of centimeters making episodic seepage very likely.

Moreover, for the appreciably tall (i.e., greater than or equal to 5m) fracture-bounded tuff blocks (*cf*., Dunne, W.M., Ferrill, D.A., Crider, J.G., Hill, B.E., Waiting, D.J., La Femina, P.C., Morris, A.P. and Fedors, R.W. (Dec. 2003) "Orthogonal Jointing During Coeval Igneous Degassing and Normal Faulting," GSA BULLETIN, Vol. 115, No. 12 at 1492–1509, and Throckmorton, C.K. and Verbeek, E.R. (1995) "Joint Networks in the Tiva Canyon and Topopah Spring Tuffs of the Paintbrush Groups, Southwestern Nevada," U.S. Geological Survey Open-File Report 95-2, 182 pages), a mechanism akin to gas-oil gravity drainage (where oil is the wetting phase) is likely to drain the rock matrix utilizing the fractures as flow-focusing drains. In reservoir engineering, this process is well documented as an important oil recovery mechanism for naturally fractured reservoirs (*see, e.g.*, Wit, K., Clemens, T., and Rijkels, L. (2002) "Simulation of Gas/Oil Gravity Drainage in a Stack of Interacting Blocks: Pseudo Relations for a Limited Number of Gridblocks, SPE 77722," Annual SPE Conference, San Antonio, TX, 2002.). As an analogy between horizontal production wells and the drifts in the planned repository is plausible as a conceptual model of the system, this means that the drifts should focus rather than divert the seepage.

6. Information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsection 2.3.3 argues for a flow diversion around the repository drifts due to capillary forces, but in the presence of drift-wall fractures this is not a valid assumption which implies that more water will enter the emplacement drifts than is asserted by DOE. Specifically, DOE inappropriately argues that a capillary process analogous to the capillary end effect will divert water around the emplacement drifts, but considerations of variations in fracture aperture, the imbibing of fluids into fractures, and mechanisms akin to gas-oil gravity drainage all demonstrate that alternative conceptual models are readily justified that may result in water preferentially entering the emplacement drifts rather than being diverted around them. Thus, SAR Subsection 2.3.3 does not comply with 10 C.F.R. § 63.114(e) which requires the performance assessment to provide the technical basis for either inclusion or exclusion of specific FEPs, such as those relating to the behavior of water in fractures, nor does it comply with 10 C.F.R. § 63.114(c), which requires the performance assessment to consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that

are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(h) Geochemistry of Waters and Deposits in the Emplacement Drifts

NEV-SAFETY-67 - EVALUATION OF UNCERTAINTIES IN ESTIMATED CHEMICAL PROPERTIES, ESPECIALLY pH VALUES, OF EVAPORATED DRIFT BRINES

1. A statement of the contention itself

The modeled compositional range for evaporated brines that might seep onto waste packages, and thus be the agent for corrosion, at the end of the thermal period should be broader than has been estimated and used in SAR Subsection 2.3.5.5 and related subsections.

2. A brief summary of the basis of the contention

The uncertainties in the predicted compositions of evaporated drift brines are underestimated; this applies especially to the estimates of pH uncertainty for which a model with constant partial pressure of carbon dioxide, $P(CO_2)$, and pH directly related to total inorganic carbon, $[C]_{total}$, has been assumed.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.102(h) (part of Subpart E) states that natural and engineered barriers are required and that evaluation of performance will be based on credible

models and parameters including consideration of uncertainty. It also states that the description of each barrier's capability in performance assessment should provide understanding of how the natural and engineered barriers work in combination to enhance resiliency of the repository. 10 C.F.R. § 63.114(b) (also part of Subpart E) states that compliance with 10 C.F.R. § 63.113 must account for uncertainties and variabilities in parameter values and provide a technical basis for parameter ranges, probability distributions, or bounding values used in performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The chemical properties of brines that form by evaporation of pore waters seeping through the wall rocks into repository drifts are an input data set for the calculations of corrosion rates of drip shields and waste packages in the event that drip shields have failed. These brines would form during the long tail of the thermal period when, according to the SAR conceptual model (*see* SAR Subsection 2.3.5.5.1), seepage would no longer be prevented by boiling and instead evaporation of near field pore waters would create brines. One of the influential chemical properties with respect to corrosion rates is pH, i.e., the degree of acidity, and this contention concerns primarily the uncertainty in that parameter.

The in-drift system will reach a state towards the end of the thermal period, i.e., after temperature has dropped below boiling, when seepage through the drift walls will become saline due to evaporation and dissolution of precipitates and salts formed during the prior boiling period. Corrosion of waste packages could be significant during this state because liquid water will be present with saline or brine compositions. Therefore, knowledge of the maximum variability of brine compositions is necessary to constrain the rate of corrosion. The saline water and brine compositions have been modeled with the EQ3/6 computer program by simulating evaporation and reaction with rock of representative compositions given by 4 groupings of data for TSw pore waters. *See* "Engineered Barrier System: Physical and Chemical Environment, ANL-EBS-MD-000033 REV06" (08/31/2007), LSN# DN2002452948 at Section 6.9. The EQ3/6 simulations calculate the variations of ionic concentrations and pH in relation to variations of activity of water or relative humidity (RH). Modeled pH is the "Pitzer pH," which does not correspond with the pH values measured in validating experiments. The modeled pH is based on an assumption that it is controlled by equilibration with the partial pressure of CO_2 in the atmosphere of the drifts. *See* DN2002452948, Section 6.12.3.1.3. This does not allow for the possibility that other chemical reactions might control pH locally. The uncertainties in pH have been estimated by correlating these uncertainties with the uncertainties in total inorganic carbon concentrations, $[C]_{total}$, that are estimated from the differences between modeled values and measured values for evaporation experiments, on which basis it is suggested that the uncertainty in pH can be reduced to less than ±1 pH unit for brines that are below the salt saturation limit. *Id.*, Section 6.12.3.1.2. This is not an appropriate estimate, because it assumes no other controls on pH other than $P(CO_2)$. Modeled values for pH based on the 4 groups of starting pore water compositions, in relation to different values of water-rock interaction parameter (WRIP), of $P(CO_2)$, and temperature are in the approximate range 5 to 11 *Id.*, Figures 6.13-5 to 6.13-8, and Section 6.13.3. Given the probability that uncertainties have been underestimated, the in situ pH range could be even greater than that.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The modeled compositional range for evaporated brines that might seep onto waste packages and thus be the agent for corrosion, at the end of the thermal period should be broader than has been estimated and used in SAR Subsection 2.3.5.5 and related subsections. Thus, these subsections do not comply with 10 C.F.R. § 63.102(h), which states that natural and engineered barriers are required and that evaluation of performance will be based on credible models and parameters including consideration of uncertainty. Nor do they comply with 10 C.F.R. § 63.114(b), which states that compliance with 10 C.F.R. § 63.113 must account for uncertainties and variabilities in parameter values and provide a technical basis for parameter ranges, probability distributions, or bounding values used in performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-68 - IN-DRIFT CONDENSATION ON MINERAL DUST

1. A statement of the contention itself

SAR Subsection 2.3.5.4.2 and related subsections, which describe DOE's model for condensation, ignore condensation on surfaces of common and ubiquitous rock dust (siliceous and feldspathic) that coat EBS materials resulting in a much larger volume of liquid and vapor on these surfaces than calculated by DOE.

2. A brief summary of the basis for the contention

Proposed repository construction and desert-derived ventilation dust and mineral precipitates on the C-22 and Ti-7 surfaces can act as acceptors for condensation affecting the in-drift condensation model, because these particles have large surface areas and can therefore trap much greater concentrations of liquid than calculated by DOE.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with 10 C.F.R. Part 63 applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the license application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance

objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations to support scientific or factual materials

Geochemically benign dust can form loosely spaced crevices that are favorable physical environments for localized corrosion initiation with acid brines and vapors produced by hydroscopic salt dust and/or unsaturated zone seepage. SAR Subsection 2.3.5.4.2 defines DOE's position on condensation in the in-drift environment. Rock dust coating metallic EBS materials will have lower temperatures than the EBS materials due to density and thermal property differences. Rock dust because of its small grain-size range in diameter, will have large surface areas where a liquid skin can occur. The volume of liquids near or at the surface of C-22 and Ti-7 will be greatly affected by the association of these surfaces with dust that is associated with condensation. DOE suggests that the dust will trap and sequester acidic brine liquids derived from hydroscopic salts so that these liquids will not have the capacity to reach the EBS–metal surfaces. In this case, DOE has ignored the capillary induction behavior of condensate in dust, and consequently, the volume of liquids within the dust-field skin coating the C-22 and Ti-7 surfaces has been underestimated by DOE. This underestimation affects the validity of the in-drift condensation model. Condensate can be responsible for moving acid brine formed by hydroscopic salts within the dust field. This movement includes transport to the C-22 and Ti-7 surfaces.

The in-drift condensation model discussed in SAR Subsection 2.3.5.4.2 is intended to complement the multi-scale thermal-hydrologic model (SAR Subsection 2.3.5.4.1) in terms of evaluating the thermal-hydrologic environment and is coupled to the in-drift chemical environment models (SAR Subsection 2.3.5.5). The condensation model has not addressed the presence of dust on metal EBS surfaces. Local-scale thermal-hydrologic-geochemical variability is much greater when the presence of dust in the in-drift system is taken into account. Consequently, the overall volume of liquid and vapor phase products at the EBS metal surfaces (C-22 and Ti-7) is under represented during many phases of the thermal period. This affects the hydrogeochemical conditions on the surface of the waste form and drip shield and therefore the timescale over which they will corrode.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.5.4.2 and related subsections, which describe DOE's model for condensation, because they ignore condensation on surfaces of common and ubiquitous rock dust (siliceous and feldspathic) that coat EBS materials resulting in a much larger volume of liquid and vapor on these surfaces than calculated by DOE.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-69 - COUPLED SEEPAGE AND DUST DELIQUESCENCE

1. A statement of the contention itself

SAR Subsection 2.3.5.2 and similar subsections, which focus on coupled processes, fail to consider seepage and dust deliquescence reactions as combined processes and therefore underestimate the degree and extent of localized C-22 corrosion.

2. A brief summary of the basis for the contention

Deliquescent salt dust brines may form at peak thermal periods without sufficient liquid volume to cause C-22 corrosion; however, when seepage is coupled with salt brine production and related salt brine C-22 pit-corroded areas, C-22 corrosion failure can become critical.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. §

63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE should consider the coupled processes (*see* SAR Subsection 2.3.5.2) of dust deliquescence and in-drift seepage reactions both as truly coupled processes occurring together and as sequentially occurring processes, one after the other. These are two different conditions; and DOE in the License Application SAR considers neither.

Sequential Processes:

In the coupled process scenario where dust deliquescence occurs during the optimal thermal-chemical periods for production and metastability of calcium chloride (and other salts such as magnesium chloride, magnesium nitrate, calcium magnesium chloride, and calcium magnesium nitrate), corrosion of C-22 may be initiated during the encapsulation of these hydroscopic salts under a dust or mineral precipitate blanket. These hydroscopic salt reactions may be enhanced by thermo-hydro-chemically (THC)-modified brines from unsaturated zone seepage at later containment periods when thermal-hydrologic conditions are optimal for fracture flow seepage. DOE neglects to consider the coupling of salt deliquescence with seepage as sequentially occurring processes. The time period of initiation of a deliquescent salt (*see* SAR Subsections 2.3.5.4.1.1.3 and 2.3.5.5.1) does not limit the activity of that salt to only the period of formation. The salt may persist in the in-drift environment beyond its period of formation.

Simultaneous Processes:

In the coupled process scenario in which dust deliquescence occurs at the same time as unsaturated zone seepage (*see* SAR Subsections 2.3.5.5.4.2.1 and 2.3.5.5.4.3), deliquescent dust salts would have the capacity to change the geochemical composition of the seepage fluids at the C-22 surface. DOE neglects to consider this coupled process, as DOE assumes that the thermal conditions needed for salt deliquescence do not support seepage into the containment drift (*see* SAR Subsection 2.3.5.4.1.1.3). Specifically, in SAR Subsections SAR 2.3.5.2, 2.3.5.5.1, 2.2.1, and 2.3.5.4.1.1.3, DOE suggests that there is no seepage during the dryout period, but that dust deliquescence is possible. DOE states that seepage only becomes possible after the temperature of the wall rock of the emplacement drifts drop below 100˚C (*see* SAR Subsection 2.3.5.4.1.1.3). This is even though perched water zones may form (*see* SAR Subsections 2.3.2.1, 2.3.2.2.2.4, and 2.3.2.4.1.2.4.4), supported by capillary barriers at faults, leading to water accumulation above the containment drifts. Breakdown of such barriers could lead to non-equilibrium seepage events that are not limited by a wall rock temperature of 100˚C. In this context, SAR Subsection 2.3.3.3.1, at 2.3.3-58 presents the conceptual description of thermal-hydrologic processes and states:

> The heating of near-field rock to the boiling temperature of water and the resulting flow perturbation affects the potential for seepage. Condensed water forms a zone of slightly elevated water saturation in fractures above the dryout zone. Water from this zone may be mobilized to flow rapidly down towards the drift. However, seepage would only be possible if both the vaporization barrier in the boiling zone and the capillary barrier at the drift ceiling would be breached. Results from the thermal-hydrologic seepage model demonstrate that this scenario is not expected.

In the above DOE scenario, the head of water available in large fractures would control non-equilibrium seepage because a high hydraulic head would overcome both of the conceptual barriers (vaporization and capillary). The result obtained in this scenario depends greatly upon the parameter values used. Consequently, it is possible to generate seepage into the containment drifts during the thermal period. Therefore, there is strong reason to consider coupled processes where both dust deliquescence and seepage occur together.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.5.2 and similar subsections, which focus on coupled processes, fail to consider seepage and dust deliquescence reactions as combined processes and therefore underestimate the degree and extent of localized C-22 corrosion. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-70 - THC EVOLUTION OF NEAR-FIELD PRE-SEEPAGE UNSATURATED ZONE WATER

1. A statement of the contention itself

SAR Subsections 2.2.1, 2.3.5.5, 2.3.5.3 and similar subsections, which relate to hydrogeochemical changes in vadose fracture and matrix as a consequence of water evaporation and tuff dissolution, and thermal-hydrologic-chemical coupled processes, fail to recognize the critical significance of mineralization reactions on unsaturated zone seepage water chemistry.

2. A brief summary of the basis for the contention

DOE describes the thermal-hydrologic-chemical evolution of in-drift unsaturated zone water in some detail, but (a) fails to apply a similar philosophy to the elevated temperature chemical evolution of near-field unsaturated zone water, and as a result the aqueous chemistry of unsaturated zone waters that will contribute to seepage into the drifts is incorrectly held constant through the life of the thermally evolving repository, and (b) inappropriately uses a model to compute the aqueous chemistry of the seepage waters, which thus is not suitable for estimating the compositions of seepage waters and solid deposits that could result in the corrosion of drip shields and waste packages.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with 10 C.F.R. Part 63 applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 2.2.1, Table 2.2-5, states that FEP 2.2.08.03.0B – geochemical interactions and evolution in the UZ – has been excluded because of low consequence. This FEP deals with groundwater chemistry that may change through time as a result of the evolution of the disposal system.

However, geochemical interactions will lead to dissolution and precipitation of minerals along the groundwater flow path and these reactions will be affected by changes in the thermal envelope. By removing the changing effects of the proposed repository on geochemical interactions and the evolution of the unsaturated zone from consideration, DOE has excluded normal evaporative geochemical reactions in fracture and fault conduits leading to the emplacement drifts. At the same time, DOE has inconsistently adopted an approach to determining water composition that does account for evolving geochemical interactions, at least to some degree, based on "average" feldspar dissolution.

More specifically, SAR Subsection 2.3.5.3.3.2.10 at 2.3.5-46 summarizes the near-field chemistry model as follows:

> . . . percolating pore water moves up a temperature gradient as it approaches the drift but does not evaporate or degas significantly until water hits the isotherm representing the saturation temperature for the in-drift vapor pressure; even if that temperature is below the boiling point of water, some of the percolating water evaporates and the residual liquid becomes concentrated at that point. The water just behind the evaporation front is represented by pore water at the temperature of the interface, in equilibrium with a gas phase $_pCO_2$ predicted by ramping the water up to temperature in a closed system (i.e., no degassing), while maintaining equilibrium with calcite and amorphous silica, and titrating in an amount of feldspar determined by the thermal field and flux-dependent flow velocities. The water vapor pressure is maintained at $_p$SAT as the temperature increases, so no evaporation occurs. The near-field chemistry model predicts the composition of potential seepage water at the evaporation front, providing starting water compositions for the seepage evaporation model (Section 2.3.5.5). The evaporation front corresponds to the boiling front (96˚C) during the boiling

> period; its location is determined by interpolation between the thermal profiles described in Section 2.3.5.3.3.2.6. Once the drift wall temperature drops below boiling, it corresponds to a location at or near the drift wall.

The only chemical reactions that are possible in this DOE model during the transit of water from ground-surface infiltration to seepage (95˚C thermal isotherm) into the emplacement drifts are derived from water-rock interactions characterized solely by "average" feldspar dissolution. This model is unrealistic because evaporation will occur along the fracture pathways between surface infiltration and the 95˚C isotherm, as attested to by present authigenic mineralization along fracture and fault conduits in the unsaturated zone. This is especially true for fault and fracture systems that are presently breathing as a consequence of the normal un-perturbed geothermal gradient. Once the proposed repository is closed, the heat envelope will extend further in fracture and fault conduits and will cause a breathing flux that is expected to:

a) Provide a complex reaction zone above the proposed repository; and

b) Cause extensive evaporation from common small infiltration events and thereby change the hydrogeochemical composition of the unsaturated zone waters that are being transported by gravitational drainage.

Consequently, the modern-day unsaturated zone water is inappropriately defined on the basis of four water types from 34 samples classified by DOE as "unjustified" (*see* SAR Subsection 2.3.5.5.2).

Rather than arbitrarily limiting the percolating unsaturated zone water chemistry, it would be appropriate to use a modification of the in-drift model (*see* SAR Subsection 2.3.5.5), as this more closely (with thermal modifications) describes the transit path of THC reactions than does the selection of 34 pore-water chemical compositions and then forcing them to describe fracture flow hydrogeochemical compositions in a perturbed thermal environment.

In particular, in adapting this model, it is noted that when unsaturated zone fracture flow water forms a film on the surface of the fracture walls (either elevated in temperature or with thermally driven air circulation), under conditions where infiltration is low, it is likely that this water will evolve by spatial evaporative mineral separation and that even the most soluble aqueous components may precipitate. With the next storm infiltration event, the most soluble salts will go back into solution leaving fracture mineral coatings of silicates (opal), sulfates (gypsum), and carbonates as pore and microfracture fillings and fracture/fault wall rock coatings. This process will occur to an increasing extent as the rock wall temperatures rise above ambient due to repository heating. Consequently, seepage water chemistry will be likely to evolve in response to the dynamic changes in the thermal envelope, and the concentrations of chlorides and nitrates will rise as a function of selective mineralization along flow pathways (nitrate concentrations may be reduced by bacterial action in the zone above the repository).

Finally, as normal evaporative precipitation from meteoric water has produced opal and calcite in fractures such as found in trench-14, the process of authigenic mineralization along fracture pathways from infiltration is not a new concept in the Yucca Mountain area, since this effect has been observed *in situ*.

In summary, DOE does not provide a coherent statement on the evolution of seepage water chemistry. It excludes this from consideration in the FEP analysis, but then sets out a model that explicitly invokes the time-evolving temperature gradient. However, that model is inappropriate and inadequate for estimating the chemical composition of seepage waters. In turn, this implies that the model is not suitable for use in estimating the compositions of seepage waters and solid deposits that could result in the corrosion of drip shields and waste packages.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsections 2.2.1, 2.3.5.5, 2.3.5.3 and similar subsections, which relate to hydrogeochemical changes in vadose fracture and matrix as a consequence of water evaporation and tuff dissolution, and thermal-hydrologic-chemical coupled processes, fail to recognize the critical significance of mineralization reactions on unsaturated zone seepage water chemistry. In consequence, these subsections do not comply with 10 C.F.R. §§ 63.21(c)(3)(ii), 63.21(c)(14), 63.102(h), 63.113, 63.114(f) and 63.115, which requires that any performance assessment must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many

thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-71 - MICROBIALLY INDUCED WATER CHEMISTRY CHANGES IN THE INCUBATOR ZONE

1. A statement of the contention itself

SAR Subsection 2.3.5 and similar subsections, which deal with the near-field chemistry model, fail to recognize the potential role of microbial communities in determining unsaturated zone water chemistry in the near-field environment.

2. A brief summary of the basis for the contention

Denitrifying bacteria have the capability to increase the Cl^- to NO_3^- ratio in their environment by converting nitrate to reduced oxides or N_2, thereby changing the aqueous nitrate to chloride ratio prior to seepage into the emplacement drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The incubator zone is a zone of elevated temperature, possibly associated with perched groundwater, or with fluid films or skins along the wall rock of fractures. This zone is uneven in its boundary conditions, and dynamic in response to the thermal output of the in-drift environment. This zone is below the temperature of the in-drift environment but above the temperature of the natural environment. As a consequence of the elevated temperature and moisture flux, bacterial and fungal activity will be increased. This activity has the potential to change the hydrogeochemistry of the unsaturated zone fluids reaching the in-drift environment via fracture flow mechanisms.

Denitrifying bacteria have the capability to increase the Cl^- to NO_3^- ratio in their environment by converting nitrate to reduced oxides or N_2, thereby changing the aqueous nitrate to chloride ratio prior to seepage into the emplacement drifts. *See* "A Perspective on the Use of Anion Ratios to Predict Corrosion in Yucca Mountain" (08/01/2003), LSN# NEV000004014 at 1-4.

DOE has not evaluated the role of bacteria or fungi in changing the chemical properties of unsaturated zone fluids that have a role in drip shield and waste package degradation and radionuclide transport. Consequently, DOE characterization of the near-field is inadequate and inappropriate. It is likely that the nitrate/chloride ratios used by DOE to describe corrosion inhibition are wrong.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.5 and similar subsections, which deal with the near-field chemistry model, fail to recognize the potential role of microbial communities in determining the water chemistry of the near-field environment. This means that the range of nitrate to chloride ratios used by DOE to describe corrosion inhibition is wrong. In consequence, SAR Subsection 2.3.5 and similar subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-72 - CHARACTERIZATION OF DUST SOURCES

1. A statement of the contention itself

SAR Subsections 2.3.5, 2.3.5.1 and similar subsections, which describe the in-drift physical and chemical environment, fail to consider dust as an important physical factor in the in-drift environment and have poorly characterized the genesis of dust in that environment.

2. A brief summary of the basis for the contention

The in-drift physical and chemical environment defines the environmental conditions under which the EBS must function to inhibit or reduce the rate of radionuclide movement to the accessible environment. DOE has inappropriately limited its characterization of dust in emplacement drifts and thereby has inappropriately and inaccurately characterized the EBS environment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and

Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE only discusses dust in relation to hydroscopic mineral salts that have the potential to corrode C-22. The origin of these salts is presumed to be either from ventilation or from construction activity. Even this aspect of the dust is not well characterized (*see* SAR Subsection 2.3.5.1) and other sources of dust are entirely neglected. These failures of characterization have important implications, *e.g.*, for assessing modes and rates of corrosion of drip shield and waste packages. For example, DOE excludes dust deliquescence from evaluation in the TSPA (FEP 2.1.09.28.0A, Localized corrosion on waste package outer surface due to deliquescence) because it was determined to be insignificant to performance due to the presumed dilution of acid vapors into the tunnel atmosphere and due to the presumed small quantities of brine from the small volume of available calcium chloride dust present. The characteristics of the dust environment, including the genesis, geochemistry, physical attributes and distribution of the dust, are important properties and without detailed information on them the exclusion of dust deliquescence in the in-drift environment cannot be justified. DOE has not provided this basic characterization. In this absence, the in-drift physical and chemical environment is poorly and inadequately characterized and this then provides an inadequate basis for specifying assessment calculations.

In contrast to DOE's position, it is contended that the role of dust in the waste emplacement drift environment is critical with respect to the behavior of C-22 and T-7 as components of waste packages and drip shields, respectively. The significance of dust in the containment environment extends beyond the hydroscopic salts that may be present in the dust. Factors of relevance include the physical attributes and trace element content of the dust, and the relations of these properties to corrosion of C-22 and Ti-7.

There are four direct sources of dust in the in-drift environment:

1) Rock and mineral dust from construction activities;
2) Rock, mineral, and organic dust from ventilation;
3) Decomposed EBS debris dust due to corrosion (for example of rock bolts); and
4) Salt dust and debris from evaporite scale deposits falling from the ceiling and walls of tunnels.

The trace element geochemical composition of each of these deposits remains unknown because there has been no characterization of them. The mineral content of some of these deposits can be ascertained from the basic understanding of their genesis. The relative volume and hence importance of each of the four different dust deposits is unknown, and therefore, the range in quantity of deliquescent salts that might be expected in the in-drift environment has not been adequately ascertained. As a consequence, the exclusion of dust deliquescence is premature, as DOE bases this on the small deliquescent dust volumes found in limited field-testing by the USGS. Calcium chloride dust concentrations from evaporative salt production (item 4 above) have not been studied, and these concentrations would depend upon the seepage flux and volume, which has to be based upon a variety of other parameters. This information is not included in the License Application. The genesis of dust, its range in geochemical composition and its mineral content remain poorly characterized by DOE.

The potential concentrations of deleterious trace elements in decomposed EBS dust have not been ascertained because trace element data concerning the man-made materials that will be present in the in-drift environment are not available, and the corrosion or degradation of these materials has not been adequately studied under anticipated repository conditions. This information is not included in the License Application.

The overall geochemical and mineralogical characterization of dust accumulation in the in-drift environment by DOE has been inadequate and therefore the characterization of the corrosion environment for critical EBS materials is incorrect.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsections 2.3.5, 2.3.5.1 and similar subsections, which describe the in-drift physical and chemical environment, fail to consider dust as an important physical factor in the in-drift environment and have poorly characterized the genesis of dust in that environment. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

NEV-SAFETY-73 - IN-DRIFT ORGANIC CONTRIBUTION BY VENTILATION OR UNSATURATED ZONE WATER

1. A statement of the contention itself

SAR Subsection 2.3.5.5 and similar subsections, which describe the in-drift chemical environment models, fail to include organic components in the composition of unsaturated zone water, or ventilation dust in the in-drift environment, and therefore omit these components from all of their experimental and model-based estimates of corrosion and other factors influencing repository performance.

2. A brief summary of the basis for the contention

DOE's geochemical-hydrogeochemical characterization of the in-drift environment is incomplete, and the corresponding characterization of the corrosion of C-22 and related EBS components, and the transportation of radionuclides is rendered inadequate by the lack of attention to natural organic compounds derived from ventilation dust and fracture flow seepage.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The effects of organics in the waste emplacement environment on EBS materials are unknown, because DOE has not made any reasonable attempt to identify and quantify organics in the in-drift environment. The concept is that organics are only important for microbially induced corrosion (MIC), as they are only discussed in that context. This fails to address a variety of important reactions including the role of organic acids in corrosion, the complexity of organics with transition metals, the formation of colloids, and the distribution of complexes such as, but not limited to, methyl mercury. The role of organics and nanobacteria during the formation of carbonates is also of potential importance in the near field. As a consequence of the omission of consideration of these various issues, the hydrogeochemical and geochemical characterization of the in-drift and near field environments is incomplete and inadequate and the conclusions drawn by DOE concerning the corrosion performance of the EBS, the transport and potential retardation of radionuclides in the in-drift environment, and the overall performance of the repository, have been compromised.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.5.5, and similar subsections that describe the in-drift chemical environment models, fail to include organic components when specifying the composition of unsaturated zone water or ventilation dust to the in-drift environment, and therefore omit these components from all of their corrosion experiments and modeling studies. However, organic acids and organic solid particles will be present in the in-drift environment. They have the ability to enhance bacterial metabolism, promote radionuclide transport by colloidal action, and have the capacity to increase the extent of corrosion reactions due to dust on C-22 surfaces, rock bolts, and other critical areas. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

(i) Effects of Microbial Activity in the Unsaturated Zone and Repository

NEV-SAFETY-74 - IMPACT OF MICROBIAL ACTIVITY

1. A statement of the contention itself

SAR Subsection 2.3.6.3.3.2, and similar subsections, which predict limited microbial activity in the repository, and therefore, limited impact on drift chemistry and the waste package, ignore the archaea, resulting in an underestimation of the potential for microbial activity and microbially influenced corrosion.

2. A brief summary of the basis for the contention

The conditions that DOE cites as inhibitory for microbial (bacterial) growth in the repository, i.e., elevated temperature, radiation fields, low humidity and limited nutrients, does not consider the presence of archaea extremeophiles that not only tolerate but grow optimally in habitats normally considered too severe for life, *e.g.*, hot springs and salt lakes.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) and 10 C.F.R. §§ 63.113 and 63.114 (the latter two part of Subpart E) require a performance assessment. 10 C.F.R. § 63.114 (also part of Subpart E)

requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of data related to the geology, hydrology, and geochemistry (including disruptive processes and events) of the Yucca Mountain site, and the surrounding region to the extent necessary, and Section 63.114(b) requires that account should be taken of uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. Also, 10 C.F.R. § 63.114(f) requires provision of the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Conclusions in SAR Subsection 2.3.6.3.3.2 are based on data presented in DOE reference "Evaluation of Potential Impacts of Microbial Activity on Drift Chemistry ANL-EBS-MD-000038 Rev. 01" (11/18/2004), LSN# DN2002308488. Much of the information about microorganisms specific to Yucca Mountain is taken from Horn, *et al.* (2003). (*See* "Comparison of the Microbial Community Composition at Yucca Mountain and Laboratory Test Nuclear Repository Environments" (10/09/2002), LSN# DEN000027985.)

The relationships among organisms have been summarized in the form of a universal phylogenetic tree comprised of three domains: eukaryotes, bacteria and archaea. The microorganisms involved in microbiologically influenced corrosion are from all three branches of evolutionary descent. Archaea are a group of single-celled microorganisms. Archaea and bacteria are similar in size and shape, although a few archaea have unusual shapes, such as the flat and square-shaped cells. Despite the visual similarity to bacteria, archaea possess genes and several metabolic pathways that are unique.

Horn, *et al.* (2003) (DEN000027985 at 4) characterized the bacterial community at Yucca Mountain using 16S rRNA amplified with a eubacterial forward primer and a universal primer. Eubacteria means "true bacteria." The phylogenetic tree in Figure 3 in the original paper by Horn, *et al.* (2003) is labeled the "Phylogenetic tree of YM bacterial community. . ." The same diagram is presented in DN2002308488, Figure 6.3-2 at 6-17, but the figure has been relabeled "Phylogenetic Tree of Yucca Mountain Microbial community. . ." The tree presented in Horn, *et al.* (2003) (DEN000027985, Figure 3), and DN2002308488, Figure 6.3-2 at 6-17 does not identify fungi (eukaryotes) and archaea. Many of the limitations for microbial activity in the repository are based on the assumption that the microbial population is limited to eubacteria. For example, DN2002308488, Section 6.4.1 at 6-19 describes temperature and pressure constraints for the growth of bacteria as follows, "The maximum temperature at which known microorganisms can exist in an active state is 110˚C." However, archaeal strain 121 grows at 121˚C. *See* Cowan, D.A. (2004), "The Upper Temperature for Life – Where Do We Draw the Line?" TRENDS IN MICROBIOLOGY, Vol. 12, No. 2 at 58-60. DeLong has suggested that archaea "exist in a wide variety of terrestrial, freshwater, and marine habitats, sometimes in very high abundance." DeLong, E. (2003), "Oceans of Archaea," ASM NEWS, Vol. 69, No. 10 at 503-511.

DN2002308488 at 6-2 includes a description of bacterial carbon fixation of carbon dioxide (CO_2) through a Calvin cycle that "requires a considerable investment of energy" and "is probably slow." However, bacteria and archaea have developed alternative mechanisms for carbon fixation that have varying sensitivities to oxygen. Archaea can use a variety of energy sources to fix carbon including oxidation of ammonia or hydrogen sulfide using either oxygen or metal ions as electron acceptors.

The wide range of distinctive metabolic pathways used by the archaea mean that they can have distinctive effects on corrosion processes and water chemistry that could substantially enhance the degradation rates of engineered barrier components and also modify radionuclide release and transport mechanisms.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The contention challenges SAR Subsection 2.3.6.3.3.2 (at 2.3.6-25 through 2.3.6-27), and similar subsections, that describe microbial activity in the repository as "limited" and challenges all similar and related sections describing the predicted microbial populations in the closed repository, and the impact of microorganisms on the environment and the integrity of the waste container. SAR Subsection 2.3.6.3.3.2 is incomplete because it ignores a domain of microorganisms that grow optimally in extreme conditions that could develop in the repository. As a result potential microbial activity and impact in the repository is underestimated. Thus, this subsection does not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, this subsection does not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment. In addition, SAR Subsection 2.3.6.3.3.2 does not comply with 10 C.F.R. § 63.114(f), which requires provision of the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment.

NEV-SAFETY-75 - MICROBIALLY INFLUENCED CORROSION MODEL

1. <u>A statement of the contention itself</u>

The model described in SAR Subsection 2.3.6.3.3.2 and DOE reference "General Corrosion and Localized Corrosion of Waste Package Outer Barrier, ANL-EBS-MD-000003 Rev. 03" (07/25/2007), LSN# DN2002460404, to calculate an enhancement factor for microbially influenced corrosion as a multiplier to a general corrosion rate is not a standard or recommended practice and cannot be used to estimate localized corrosion resulting from the presence and activities of microorganisms.

2. <u>A brief summary of the basis for the contention</u>

The electrochemical testing described in SAR Subsection 2.3.6.3.3.2 at 2.3.6-25 through 27 and DN2002460404 Section 6.4.5.2 at 6-111 cannot be used to develop a model for microbially influenced corrosion because of the following: (1) the technique is applicable to general corrosion; (2) bacterial cells were applied to the electrode surface before the electrochemical testing; (3) no attempt was made to compensate for solution resistance before calculation of corrosion rate; and (4) the testing did not include adequate controls.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) and 10 C.F.R. §§ 63.113 and 63.114 (the latter tow part of Subpart E) require a performance assessment. 10 C.F.R. § 63.114(a) requires the inclusion of data related to the geology, hydrology, and geochemistry (including disruptive processes and events) of the Yucca Mountain site, and the surrounding region to the extent necessary, and Section 63.114(b) requires that account should be taken of uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

A model developed to estimate the alteration of corrosion rates of Alloy 22 due to microbially influenced corrosion (MIC) at Yucca Mountain is described in SAR Subsection 2.3.6.3.3.2 and DOE reference "General Corrosion and Localized Corrosion of Waste Package Outer Barrier, ANL-EBS-MD-000003 Rev. 03" (DN2002460404). In the model, MIC is treated as an enhancement of a general corrosion rate and the enhancement factor is established using data from Lian, T., Martin, S., Jones, D., Rivera, A., and Horn, J. (1999). *See* "Corrosion of Candidate Container Materials by Yucca Mountain Bacteria" (02/05/1999), LSN# DEN000045571.

Lian, *et al.* (1999) (DEN000045571), Figure 6, at 16, compared general corrosion rates derived from polarization resistance measurements of C-22 electrodes with and without bacteria. In describing their experimental procedures, Lian, *et al.* (1999) (DEN000045571) at 2-3 did not cite a standard. However, the current ASTM standard for conducting polarization resistance measurements is ASTM Standard G59-97 (2003), "Standard Test Method for Conducting Potentiodynamic Polarization Resistance Measurements," ASTM International, West Conshohocken, PA. ASTM G59-97 (2003) at 1, states, "Polarization resistance measurements are an accurate and rapid way to measure the general corrosion rate." Most microbially influenced corrosion is localized corrosion, *e.g.*, pitting, crevice corrosion or under-deposit corrosion. For example, DN2002460404 in Fig. 6-55 at 6-113, includes images from Martin, *et al.* (2004) ("Micron-Scale MIC of Alloy-22 After Long-Term Incubation in Saturated Nuclear Waste Repository Microcosms," LSN# DN2001707841 at 1-17) of micropits on an Alloy 22 surface. DN2002460404 at 6-113 to 6-114 states, "Coupons incubated in the non-sterile microcosm reactors developed micropits, primarily along the ridges formed by polishing, while coupons incubated in sterile microcosms and those that were not reacted in microcosms showed no evidence of micropit formation."

ASTM G59-97 (2003) at 3 specifies the bias due to solution resistance (i.e., low conductivity media) that results in an overestimation of polarization resistance and an underestimation of corrosion rates. Current interruption methods can compensate for solution resistance. However, there is no indication in Lian, *et al.* (1999) (DEN000045571) that solution resistance was resolved. Polarization resistance data were converted to a corrosion rate and averaged. The data are presented in DN2002460404, Tbl 6-16 at 6-112. The average corrosion rate (μm/yr) for the sterile Alloy 22 was 0.011 and for Alloy 22 + Yucca Mountain microbes, 0.22. Based on these results the enhancement factor of 2 was established.

The method Lian, *et al.* (1999) (DEN000045571 at 2) used to evaluate the electrochemical impact of microorganisms on electrode surfaces is not a standard practice.

"Twelve strains of YM bacteria, including acid, slime, and sulfide producers, as well as iron-oxidizing bacteria (Table 2) were mixed and applied to coupon surfaces. Microbial cell densities were established before aseptically combining and spreading a defined number (at least 10^8 bacterial cells of each strain) of all isolates on specimens which were air dried before they were exposed to growth media in corrosion cells." It is not clear whether the authors air-dried the coupons before or after spreading the cells on the surface. In any case, spreading cells on a surface before exposure to growth media cannot have the same electrochemical impact as allowing a biofilm with living cells to form. Lian, *et al.* (1999) (DEN000045571 at 2) state that the medium used for their experiments was R2 with 0.5% glucose and 0.75% protease peptone in 100X simulated J-13 well water. R2 typically contains the following in g/L, yeast extract 0.5; proteose peptone 0.5; casein hydrolysate 0.5; soluble starch 0.5; sodium pyruvate 0.3; dipotassium hydrogen phosphate 0.3 and magnesium sulfate 0.05. Lian, *et al.* (1999) (DEN000045571) do not describe any procedure for separating cells from culture medium and specifically eliminating yeast extract from the medium in which electrochemical measurements were made. Webster, B.J. and Newman, R.C., "Producing Rapid Sulfate-Reducing Bacteria (SRB)-Influenced Corrosion in the Laboratory" (1994), Microbiologically Influenced Corrosion Testing, ASTM STP 1232, Eds. J.R. Kearns and B.J. Little, at 33, suggested that yeast extract caused interferences on electrochemical measurements in their experiments. DN2002460404 at 6-111 describes a different growth medium for the Lian, *et al.* (1999) (DEN000045571) experiments. Neither reference clearly states the electrolyte for the Lian, *et al.* (1999) (DEN000045571) electrochemical experiments. It is clear that Lian, *et al.* (1999) (DEN000045571) did not conduct essential control experiments – evaluating the impact of the R2 (containing yeast extract), glucose or protease peptone on the electrochemical measurements.

The experiments described in Lian, *et al.* (1999) (DEN000045571) lasted approximately five months. At the end of the experiments no attempt was made to verify that the uninoculated media were sterile. The coupons were not checked for contamination. It is extremely difficult to maintain sterile controls in enriched media over long periods of time. If the controls were contaminated the corrosion rates for the controls would not represent corrosion rates in the absence of bacteria.

DN2002460404 at 6-111, 112, does describe additional experiments in which welded Alloy 22 coupons were exposed to 100X J-13 well water plus 0.1% glucose with and without microorganisms from Yucca Mountain. The results of the electrochemical tests are described at 6-111 through 6-112 as "conservative" because of the addition of 0.1% glucose as an additional nutrient that would not be in the Yucca Mountain repository. However, it is well established that glucose can inhibit the growth of some microorganisms. Marchand, E.A. and Silverman, J. (2003), "The Role of Enhanced Heterotrophic Bacterial Growth on Iron Oxidation by *Acdithiobacillus ferrooxidans*," GEOMICROBIOLOGY JOURNAL, Vol. 20 (3) at 231-244. Furthermore, Horn, *et al.* (2003), "Comparison of the Microbial Community Composition at Yucca Mountain and Laboratory Test Nuclear Repository Environments" (10/09/2002), LSN# DEN000027985 at 6, state that with the addition of 0.1% glucose, "Most of the organisms grown in 1XJ13 Synthetic with glucose differed from those isolated from 1XJ13 without glucose. In summary, media 0.1% glucose may inhibit the growth of some microorganisms found in Yucca mountain rocks."

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The contention challenges SAR Subsection 2.3.6.3.3.2 and DN2002460404 Section 6.4.4 that describe a model for predicting the rate of microbially influenced corrosion as a multiplier to the general corrosion and challenges all similar and related sections describing the model and conclusions drawn from the use of the model. The model and the multiplier are based on flawed electrochemical experiments that do not represent any condition of microorganisms on a surface in the repository. As a result the potential for microbially influenced corrosion is underestimated. Thus, SAR Subsection 2.3.6.3.3.2 does not comply with 10 C.F.R. § 63.114(a), which requires the performance assessment to include data related to the geology, hydrology and geochemistry of the Yucca Mountain site and the surrounding region to the extent necessary. Also, SAR Subsection 2.3.6.3.3.2 does not comply with 10 C.F.R. § 63.114(b), which requires the performance assessment to account for uncertainties and variabilities in parameter values, and provide for the technical bases for parameter ranges, probability distributions, or bounding values used in the performance assessment.

NEV-SAFETY-76 - MICROBIAL DENITRIFICATION

1. A statement of the contention itself

DOE underestimates some important modes of corrosion that depend on nitrate concentrations in SAR Subsection 2.3.6.4, and similar subsections, because of the conclusion in SAR Subsection 2.3.6.3.3.2, at 2.3.6-25, that oxic conditions will prevail in the repository over the growth-permissive high humidity and cooler period, and because of the erroneous assumption that microbial denitrification of nitrate is a strictly anaerobic process.

2. A brief summary of the basis for the contention

Conclusions about microbial activity in SAR Subsection 2.3.6.3.3.2, based on "Evaluation of Potential Impacts of Microbial Activity on Drift Chemistry ANL-EBS-MD-000038 Rev. 01" (11/18/2004), LSN# DN2002308488 at Section 6, describing the repository as oxic (i.e., containing oxygen) do not account for oxygen gradients due to aerobic respiration and do not consider aerobic denitrification.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E

of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) and 10 C.F.R. §§ 63.113 and 63.114 (both part of Subpart E) require a performance assessment. 10 C.F.R. § 63.114(b) requires the performance assessment to account for uncertainties and variabilities in parameter values and to provide the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. 10 C.F.R. § 63.114(c) requires consideration of alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and evaluation of the effects that alternative conceptual models have on the performance of the geologic repository. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Based on the evaluations described in DN2002308488, the overall chemical environment in the repository is described in SAR Subsection 2.3.6.3.3.2 as oxic, and therefore significant anaerobic activity is described as unlikely. There is recognition in DN2002308488 of the following: (a) metal corrosion will consume oxygen (*id*. at 1-2); (b) some bacteria can survive intense radiation and will grow when conditions are favorable (*id*. at 6-33 - 6-35); (c) bacteria create their own environments by forming biofilms (*id*. at 6-32); and (d) there is possibility of limited microbial activity (*id*. at 7-2). However, there is no recognition that oxygen gradients will form due to respiring aerobic microorganisms.

Lewandowski, Z. and Beyenal (2007), "Fundamentals of Biofilm Research" (CRC Press Taylor & Francis Group, 6000 Broken Sound Parkway N.W., Suite 300, Boca Raton, FL 33487) at 87, measured oxygen profiles from the bulk medium through biofilms and demonstrated a distinct decrease in oxygen concentration at the biofilm/water interface. Also, oxygen gradients exist in many oxygenated media, for example open oceans.

DN2002308488 at 6-32 cites the work of Else, *et al*. (2003), as a demonstration that a combination of low relative humidity and high temperature will inhibit biofilm formation. *See* Else, T.A., Pantle, C.R., and Amy, P.S. (2003), "Boundaries for Biofilm Formation: Humidity and Temperature," APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Vol. 69(8) at 5006-5010. Else, *et al.* (2003), exposed metal surfaces to microcosms containing crushed rock and maintained the microcosms at 100%, 84%, 70.5% and 32% relative humidity at 30°C, 60°C and 70°C. Biofilm formation was evaluated using heterotrophic plate counts and scanning electron microscopy (SEM). Sample preparation for SEM required air-drying of the biofilms for 24 hours. "When viewed by SEM, only small patches of biofilm formed on C22, N-316 and titanium coupon surfaces under conditions of less than 100% RH at 30°C." Else, *et al.* (2003) at 5007.

However, because of biofilm dehydration, SEM cannot be used to quantify biofilm area coverage and thickness. *See, generally*, Little, B.J., Wagner, P.A., Ray, R.I., Pope, R., and Scheetz, R. (1991), "Biofilms: An ESEM Evaluation of Artifacts Introduced During SEM Preparation," J. INDUSTRIAL MICROBIOLOGY AND BIOTECHNOLOGY, Vol. 8, No. 4 at 213-221. Heterotrophic plate counts can account for only a small percentage of naturally occurring heterotrophic microorganisms. The experiments demonstrate a relationship between relative humidity, temperature and biofilm formation. However, the microorganisms were not acclimated to the environmental conditions of the experiments. Therefore, it is not clear that the Else, *et al.* (2003) experiments can be related to Yucca Mountain or that they can be used to substantiate the claim that there will be no biofilm formation in the repository.

Oxygen (O_2) and nitrate (NO_3^-) are the two energetically most favorable electron acceptors found in nature. Microorganisms can reduce NO_3^- to nitrogen gas through a process of denitrification. DN2002308488, Section 6.4.2 addresses the microbial aspects of FEP 2.1.09.06.0B (reduction-oxidation potential in drifts), stating, "Nitrate (NO_3^-) is an inhibitor for metal corrosion as opposed to chloride (Cl^-) as summarized in *General Corrosion and Localized Corrosion of the Waste Package Outer Barrier* (BSC 2004 [DIRS 169984], Section 1.2). The ratio of NO_3^-/Cl^- is an important parameter in the control of the longevity of the waste package and drip shield as engineered barriers. In principle, microorganisms could consume nitrate through denitrification, either heterotrophically or autotrophically, under anaerobic conditions (Korom 1992 [DIRS 172324] at 1657-1668)." DN2002308488, Section 6.4.2 at 6-22. It has previously been stated that "within the time window permissive for microbial activity . . . the oxygen concentration in the repository will be maintained . . . . The overall chemical environment in the repository will therefore be oxic, and a significant anaerobic microbial activity will be unlikely." *Id*. at 6-22. In addition, denitrification is defined as an anaerobic process that will be limited in the oxic environment. *Id*.

However, Robertson, *et al.* (1988) report that denitrification can occur in fully aerobic conditions with a wide range of bacteria. *See*, *generally*, Robertson, L.A., van Niel, E.W., Torremans, R.A.M., and Kuenen, J.G. (1988), "Simultaneous Nitrification and Denitrification in Aerobic Chemostat Cultures of *Thiosphaera pantotropha*," APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Vol. 54, No. 11 at 2812-2818. In addition, Robertson and Kuenen (1984) identified a denitrifying mixotroph capable of simultaneously "utilizing nitrate and oxygen as terminal electron acceptors in respiration." *See* Robertson, L.A. and Kuenen, J.G (1984), "Aerobic Denitrification: A Controversy Revived," ARCH MICROBIOL, Vol. 139 at 351-354.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsections 2.3.6.4.3.1.1 (at 2.3.6-34), based on DN2002308488, Section 6, and all similar and related sections, that do not account for the possibility of anaerobic respiration and that inaccurately define denitrification as a strictly anaerobic process. The contention also challenges all models that use the corrosion inhibition of the nitrate ion to predict that there will be no localized corrosion susceptibility for Alloy 22. These SAR subsections do not comply with 10 C.F.R. § 63.114(b), which requires that account should be taken of uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. Also, these SAR subsections do not comply with 10 C.F.R. § 63.114(c), which requires consideration of alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and evaluation of the effects that alternative conceptual models have on the performance of the geologic repository.

(j) Corrosion

NEV-SAFETY-77 - CORROSION FROM ROCK BOLT SEEPAGE

1. A statement of the contention itself

SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system in the emplacement drifts, fail to mention or consider the fact that the Super Swellex™ are hollow and would act as a conduit for seepage into the emplacement drifts and the neglect of this process means that the TSPA-LA assumptions relating to isolation of the wastes within the waste package are unfounded.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that seepage from the roof of the emplacement drifts will not be an issue during the period prior to the placement of the drip shields. This assumption ignores the fact that friction-type rock bolts are hollow and therefore represent a direct conduit from the rock mass beyond the relaxed zone surrounding the opening to the emplacement drift.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.4 at 1.3.4-8 discusses the permanent ground support system, which consists of 3-m long, Super Swellex-type friction rock bolts together with Bernold sheets. Both the rock bolts and Bernold sheets are specified as being constructed of Type 316 stainless steel. SAR at 1.3.4-10 states that the final ground support system will be installed before the placement of the invert structures. However, there is no mention of potential issues due to seepage prior to the installation of the drip shields. SAR Subsection 1.3.4.7 at 1.3.4-26 states that the drip shields will be installed as part of the closure process for the repository. The apparent implication is that there is no need to address seepage prior to that time. This suggests either that seepage is not considered to be a significant problem or that the waste packages are sufficiently corrosion resistant to withstand the corrosion generated by seepage. However, there is no discussion of any calculations or modeling having been performed to support these conclusions. In addition, nowhere is there mention that friction-type rock bolts are hollow and that, when expanded, the outside perimeter of the rock bolts will not be entirely in contact with the surrounding rock. As a consequence, there are pathways within the rock bolts that can directly transfer water at 3 m and further from the opening to the drifts. Thus, the potential for corrosion of the waste packages is understated. Because the waste package is a component important to waste isolation (IWTI) as stated in SAR Subsection 1.3.4 at 1.3.4-1, the net effect is an inaccurate assessment of the ability of the EBS system to isolate the waste.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system in the emplacement drifts because they fail to mention the fact that the Super Swellex™ are hollow and will not be in total contact with the walls of the boreholes, so that they would act as a conduit for seepage into the emplacement drifts. Because this has not been considered, the TSPA-LA assumptions relating to isolation of the wastes within the waste package are unfounded. Thus, the SAR does not comply with 10 C.F.R. § 63.114(a), which requires the inclusion of information on the design of the engineered barrier system, where this information is to be used in a performance assessment to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform.

Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-78 - STATIC CORROSION TESTS ON ALLOY 22

1. A statement of the contention itself

SAR Subsection 2.3.6.3 and similar subsections, which describe long-term weight loss measurements of the outer corrosion resistant material, alloy C-22, of the waste canister at the long-term test corrosion facility, fail to adequately represent the corrosion environment that is expected in a mined geologic repository situated in the unsaturated zone.

2. A brief summary of the basis for the contention

Static corrosion tests on coupons of the C-22 alloy under saturated conditions at the long-term corrosion test facility are unrealistic, non-site specific, and non-conservative representations of the physico-chemical environment expected for the waste canisters in a repository situated in the unsaturated zone.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and

Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Long-term corrosion tests performed on samples of the canisters' outer material, C-22 alloy, employed weight loss measurements to determine the rate of corrosion (SAR Subsection 2.3.6.3 beginning at 2.3.6-19). These experiments were conducted in large vats at two different temperatures (60° and 90°C), but the coupons were situated below the water line, that is, under static saturated aqueous conditions (except for those coupons right at and above the water line). This is not the environment that the waste canister at Yucca Mountain will be situated; waste canisters will be placed in the mined geologic repository hundreds of meters above the water table in the vadose or unsaturated zone. Under realistic conditions in the unsaturated zone, the outer canister material, C-22, will be subjected to a changing temperature (up to 200°C), high humidity conditions, with dripping seepage water (once-through flow) of possibly varying chemical compositions (due to fractionation on the canisters' surface). Between drips the aqueous solutions may dry out leaving behind salt deposits that may interact with accumulated dust deposits on the canister surface. Rock fall and drip shield material may also be in contact with the outer canister material. Thus, the actual physico-chemical surface environment of the waste canisters will most likely differ significantly from the static saturated test conditions, with the result that the test conditions are therefore unrealistic, non-site specific, and non-conservative.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges any corrosion rates for the C-22 alloy that are based on weight loss measurements at the long-term corrosion test facility as described in the SAR Subsection 2.3.6.3. DOE has not shown that these static experiments conducted under saturated aqueous conditions will yield similar results to realistic, site-specific environmental tests that include once-through water flow (of the appropriate chemistry) coupled with periodic dry-out, and with salt and dust build-up. Thus, these experiments are not an appropriate basis to assess the degradation of the EBS and do not comply with 10 C.F.R. § 63.114(f) which requires that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-79 - STATIC GENERAL CORROSION TEST SOLUTIONS

1. A statement of the contention itself

SAR Subsection 2.3.6.3 and similar subsections, which describes static long-term general corrosion tests on the waste package outer material, alloy C22, fail to address the need for and use of realistic, site-specific aqueous test solutions that are appropriate for waste packages situated in a humid, thermally perturbed, unsaturated environment.

2. A brief summary of the basis for the contention

In its long-term general corrosion static tests, DOE has used J-13 well water and related aqueous test solutions that are more appropriate for waste canisters emplaced in a saturated hydrological environment, rather than more realistic, site-specific fracture water, pore waters, or thermally evolved seepage evaporation waters.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and

Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In SAR Subsection 2.3.6.3, DOE describes the use of J-13 well water and related test waters (SAR Table 2.3.6-1) for their static long-term corrosion tests on alloy C22, the outer material of the waste package. J-13 well water is a groundwater (from the saturated zone) and is therefore a non-conservative, unrealistic, and non-site specific choice on which to base a series of test solutions. More environmentally realistic choices for long-term general corrosion aqueous test solutions would have included fracture water (none measured directly, *see* SAR at 2.3.5-30), pore waters (four groups, Near-Field Chemistry model, *see* SAR Subsection 2.3.5.3 at 2.3.5-29), and thermally evolved seepage evaporation waters (In Drift Chemical Environment Model, *see* SAR Subsection 2.3.5.5).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the use by DOE of non-conservative, unrealistic, and non-site specific aqueous test solutions in static long-term general corrosion tests on the outer material of the waste packages, alloy C22, as described in SAR Subsection 2.3.6.3, and similar and related subsections, rather than the use of more environmentally appropriate fracture, pore, and thermally evolved seepage evaporation waters for corrosion tests. Furthermore, there is no justification given that similar general corrosion rates for alloy C22 would have been obtained with the use of more conservative, realistic, and site-specific test solutions, such as pore waters or thermally evolved seepage evaporation waters. Thus, these experiments are not an appropriate basis to assess the degradation of the EBS and do not comply with 10 C.F.R. § 63.114(f) which requires that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-80 - LOCALIZED CORROSION, CHLORIDE BEARING MINERAL DEPOSITS AND HOT WALL EFFECTS

1. A statement of the contention itself

SAR Subsection 2.3.6.1.1 and similar subsections state that titanium is extremely resistant to localized corrosion due to its very passive film, and as a result, DOE has concluded that localized corrosion of titanium will not occur in repository environments and is excluded from the TSPA; DOE is incorrect because the most likely failure mode of titanium in this application is localized corrosion under insulating mineral deposits from seepage water, which has not been properly considered by DOE, that could lead to early failure of the drip shield due to penetration of the water diversion surface.

2. A brief summary of the basis for the contention

DOE's testing fails to determine the limits of the concentration, temperature, and pH conditions under which corrosion of titanium will occur and fails to address a very likely condition of a crevice created by deposits of chloride-bearing salts from seepage water evaporation, under the added conditions that at the metal surface in such a crevice the pH will be lower than in the bulk solution, the chloride concentration will be higher than in the bulk solution, and the wall of the drip shield under such insulating deposits will be hotter than a clean drip shield surface.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Also, 10 C.F.R. § 63.114(g) requires provision of the

technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.6.2.3 states that

> The localized corrosion model is based on experimental measurements of key model parameters and validated through comparison of those measurements to corroborative data that have been published in the open scientific literature. The localized corrosion model does not predict crevice corrosion even at pH of 14 (SNL 2007e, Section 6.6.3). Given the exposure conditions expected in the repository, localized corrosion of titanium alloys is not considered possible and is, therefore, excluded from TSPA (Section 2.2, Table 2.2-5, FEP 2.1.03.03.0B) (SNL 2007e, Section 6.6).

Thus, in SAR Subsection 2.3.6 and similar subsections, and documents referenced therein, DOE has stated that it is ignoring localized corrosion of the titanium. Note that pitting of titanium is usually associated with low pH, less than 1.5, not pH approaching 14.

Localized corrosion in the form of pitting, crevice corrosion, and under deposit corrosion is commonly observed in titanium in industrial applications. The specific case of salt deposits on tubing in petroleum refineries is responsible for a number of failures that have been reported in National Association of Corrosion Engineers (NACE) publications and conferences. Such failures are typically random and may affect only a portion of the tubes in a tube bundle, but render the heat exchanger unserviceable in any event. The conditions associated with the failure observed by NACE are likely to occur under conditions present at Yucca Mountain.

DOE has not adequately assessed localized corrosion, because it has failed to use tests that generate, or at least simulate, the chemistry, pH and temperature conditions that are expected to occur in the emplacement drifts. Specifically, DOE has not adequately considered the significant risk of localized corrosion of the Grade 7 Drip Shield under conditions where seepage from above evaporates on the surface, leaving mineral deposits including chloride salts to accumulate. This would result in high concentrations of chlorides, fluorides or other species, and low pH, and would be exacerbated by the hot wall effect of the heat from the canister that also results in higher surface temperatures than on a clean surface. Localized corrosion in the form of under deposit corrosion (a form of pitting) could lead to premature failure by local penetration of many drip shields, followed by localized seepage on to many of the waste packages.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the DOE position stated in SAR Subsection 2.3.6 and similar subsections that that localized corrosion of titanium will not occur in repository environments and is excluded from the TSPA. For the reasons presented above, DOE has not adequately considered the significant risk of localized corrosion of the Grade 7 Drip Shield under conditions where seepage from above evaporates on the surface. As a result, SAR Subsection 2.3.6 and similar subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Also, they do not comply with 10 C.F.R. § 63.114(g), which requires provision of the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-81 - HYDROGEN UPTAKE RESULTING FROM GENERAL CORROSION

1. A statement of the contention itself

SAR Subsection 2.3.6.8.1 and related subsections describe general corrosion of the drip shield, provide calculations of weight loss due to general corrosion, and consider the effect of thinning in terms of mechanical weakening of the structure, but DOE fails to consider the effects of localized embrittlement due to hydride formation resulting from general corrosion, and consequently DOE incorrectly assumes that the drip shield will not fail by brittle fracture resulting from rockfall or similar event.

2. A brief summary of the basis for the contention

DOE fails to address the hydrogen absorbed during general corrosion (of the corrosion allowance), which will result in hydride formation and accompanying embrittlement, and as a result DOE fails to consider the increased risk of brittle fracture due to rockfall or other external load and consequent failure of the drip shields.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

General corrosion of the drip shield is described in SAR Subsection 2.1.2.2 at page 2.1-35 as "sufficiently low that this process does not cause a through wall penetration until about two to three hundred thousand years . . . ."

Titanium general corrosion is typically accompanied by absorption of a small percentage of the hydrogen generated at the cathodic side of the corrosion reaction. For example, a titanium or titanium alloy component exposed to sulfuric acid strong enough to cause corrosion will take up hydrogen as it corrodes. The effects of the hydrogen can sometimes destroy the function of a part long before the significant corrosion allowance is consumed. Specifically, hydrogen uptake can lead to hydride formation and embrittlement, residual stresses, and cracking long before the part is consumed. The absorption of hydrogen accompanying corrosion is described on page 4-1 in "ANL-EBS-MD-000006 Revision 02, Hydrogen-Induced Cracking of the Drip Shield, September 2004 (This is a Correction to DOC.20040909.0004)" (09/07/2004), LSN# DN2001646621.

DOE has allowed 1 or 2 mm corrosion allowance, which as it is "consumed" will cause hydrogen concentrations to increase in the titanium. However, DOE fails to demonstrate that the hydrogen absorbed during general corrosion (of the corrosion allowance) will not result in hydride formation, with its consequent effects on component integrity.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges DOE’s neglect of the effects on the titanium drip shield caused by hydrogen absorption due to general corrosion, which increases the potential for brittle failure due to rockfall or other impact loads, substantially degrading the drip shield’s performance and hence increasing the predicted dose to the RMEI. Thus, SAR Subsections 2.3.6.8.1 and related subsections and DN2001646621 do not comply with 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, and do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Specifically, in its failure to address hydrogen-mediated embrittlement process, DOE has failed to comply with 10 C.F.R. § 63.114(f) which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one.

These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-82 - CORROSION OF THERMALLY OXIDIZED TITANIUM

1. A statement of the contention itself

SAR Subsection 2.3.6.8.3 and similar subsections state that the drip shield will be fully stress-relief-annealed before emplacement and describe the process to be conducted in fuel-air atmosphere at 1150°F which will result in significant surface oxide thickness compared to normal oxide films formed in air; however, DOE has failed to evaluate the effects of thermally oxidized titanium (simulating air stress relieved material that is specified as a manufacturing step intended to eliminate residual stresses assumed to eliminate stress corrosion cracking (SCC) and other hydrogen cracking issues) under the relevant repository corrosion conditions, including effects on general corrosion rates and under-deposit corrosion from seepage water evaporating on hot wall surfaces, which affect the validity of the corrosion analysis used to predict drip shield performance in the LA and could lead to early drip shield failures due to unanticipated decreased corrosion performance.

2. A brief summary of the basis for the contention

It is reasonable to expect a thermally thickened oxide resulting from stress relief at 1150°F in an air environment (likely to be two orders of magnitude thicker than a normal air film) to perform differently from a normal air formed oxide film. DOE's tests have not included titanium material in the thermally oxidized condition (simulating stress relief) and therefore they fail to duplicate the conditions of the drip shield as it will be installed in the repository.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(f) requires any performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. 10 C.F.R. § 63.114(g) further requires any performance assessment

used to demonstrate compliance with Section 63.113 to provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Thermally thickened titanium oxide films have been shown to be beneficial to corrosion resistance of titanium under some conditions under normal industrial exposures of a few years, but none of the tests described in the LA and supporting materials have attempted to simulate thermally thickened oxide under the long-term conditions involved in the repository. The performance of this thicker oxide layer and the specific effect on the material compositions and combinations of material compositions (i.e., Grade 29, Grade 7, and deposited weld metal) in the drip shield is uncertain.

Oxide growth is generally accepted to slow over time, but the effects of a pre-existing thermally enhanced oxide layer two orders of magnitude thicker that the air-formed oxide tested by DOE are unknown.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the validity of DOE long-term corrosion test results reported in SAR Subsection 2.3.6, and similar subsections, because the condition of materials tested for corrosion do not duplicate the conditions of material to be placed in the repository. DOE specifically failed to test the thermally oxidized surface condition resulting from stress relief of the titanium material, as described in SAR Subsection 2.3.6.8.3, and similar subsections. Since this is the condition of the drip shield material as it is proposed for placement, there is no demonstration of fitness for purpose which impacts the predicted dose to the RMEI. Thus, these various subsections do not comply with 10 C.F.R. § 63.114(f), which requires any performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Nor do they comply with 10 C.F.R. § 63.114(g), which further requires any performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform.

Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-83 - ADEQUACY OF METHODS OF GENERAL AND LOCALIZED CORROSION TESTING OF THE DRIP SHIELD

1. A statement of the contention itself

SAR Subsection 2.3.6 at 2.1-104 and 105 describe corrosion tests as long-term immersion exposures of open, creviced, and stressed specimens all together in closed tanks under two temperature conditions; however, the tests are not adequately representative of corrosive conditions in the proposed repository that will affect repository performance and specifically do not address the effects of Ti++ ion concentrations and aeration in the test solution that could change corrosion behavior and lead to erroneous conclusions that fail to predict corrosion performance of the actual drip shields.

2. A brief summary of the basis for the contention

The corrosion tests described do not address several issues critical to corrosion testing of titanium, such as solution replenishment (to minimize the corrosion inhibiting effects of corrosion product Ti++ in solution) or aeration conditions other than air passing over an agitated solution (which may or may not provide an air-neutral oxygen level in the solution), both common features of most modern titanium corrosion testing, nor do the tests address pH reduction, concentration increases, and hot wall effects that exist with under-deposit corrosion, and use of weight loss measurements for tests where corrosion rates are very low is prone to significant error and does not provide reasonable data on which to base even a 100-year extrapolation let alone a multi-century extrapolation of results.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(g) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Corrosion test methods used to gather data used in the models is important to the validity of the models used to justify claims of low leakage of radionuclide from the repository. The Long Term Corrosion Test Facility Tests are described in SAR Subsection 2.3.6 as consisting of fiberglass tanks of 1000 liters of solution, with aeration provided by agitation and air movement over the surface. The reader is led to believe that the specimens were immersed in the original solution for the exposure times described in the report.

The effects of titanium ions in solution were interpreted by early researchers to lead to a reduction of corrosion rates over time, a contention refuted in subsequent tests where solution replenishment was addressed. A lack of description of replenishment of solutions or of tests of alternate aeration conditions leads one to believe this important practice in titanium corrosion testing was not considered in the DOE tests described. In repository conditions, dripping solutions are constantly replenished.

Failure to replenish solutions in "beaker" corrosion tests of titanium (i.e., the 1000 liter tanks) was the source of many erroneous results in the early years before the corrosion inhibiting effect of Ti++ ion in the test solution from specimen corrosion was discovered to be critically important. Although the corrosion rates of Grade 16 or Grade 7 are low, leading to low levels of Ti++, the effect is uncertain without data as to the Ti++ levels in the test solution prior to replenishment.

DOE did not check or did not report titanium ion concentration in the test solutions, something that might have been a useful guide to very low corrosion rates.

Failure to test alternate aeration conditions fails to simulate many conditions that may be encountered, or to demonstrate that the method employed by DOE does produce fully aerated conditions (oxygen levels substantially in equilibrium with air), something that is also of critical importance in corrosion tests of titanium. Many researchers today test air aeration, but also nitrogen aeration and oxygen aeration to better quantify the aeration effects and to be certain that the effects are properly evaluated. Bubbling the air, oxygen, or nitrogen through the solution is likely more reliable in obtaining the desired conditions of dissolved oxygen than just passing air over an agitated container. Conditions of aeration in seepage solutions could well vary in areas of the drift sealed from contact with fresh air for long periods such that a range of dissolved oxygen could exist.

Use of weight loss, in the case where corrosion rates over the test period are close to nil and data are to be extrapolated for thousands of years is prone to significant error, even with very careful procedures for cleaning and weighing the specimens before and after the immersion period. The mass difference between the before and after specimens may be within the margin of error created by a fingerprint on the specimen.

The effects of changes in pH, species concentration increases, and hot wall effects that are probable under repository exposure conditions are not adequately addressed in the LA. For example, it is well known that crevice conditions result in variations in pH and oxygen concentration that are typically addressed by creating bulk solution conditions that closely duplicate the conditions expected in a crevice.

Failure to test higher temperatures to determine the actual limitations of the material proposed for the repository gives rise to the risk that variations in conditions in the actual repository and systematic deviations from the reference conditions will lead to corrosion. In general, titanium either works very well or it fails very quickly. Tests at conditions below such a threshold can be rendered completely invalid by minor changes in, for example, slightly higher temperature conditions.

Temperatures on material surfaces exposed to hot wall conditions (where there is a heat source on the opposite side of the metal surface) lead to higher surface temperatures on the metal than in the bulk solution, and it is that temperature that the metal must be capable of withstanding. This effect is exacerbated where deposits, such as mineral salts, insulate the surface from the bulk solution. In the case of chloride-containing salts, for example, the deposit can also lead to concentration of chemical species that can exacerbate corrosion, and are often seen to lead to localized corrosion. Localized corrosion failures have been observed in heat-exchange equipment due to failure to consider these effects, which is a reason why many corrosion researchers test temperatures or chemical concentrations in excess of the expected bulk solution so that they know how much margin there may be in excess of predicted bulk solution conditions.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the sufficiency of conditions tested and validity of the titanium corrosion data from the Long Term Facility Tests described in SAR Subsection 2.3.6 and similar subsections. These data are used by DOE to support its assumed performance of the drip shield in the TSPA model and thus the predicted dose to the RMEI. However, they are not valid for use in this context. Thus, SAR Subsection 2.3.6 and similar subsections do not comply with 10 C.F.R. § 63.114(g), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with empirical observations (*e.g.*, laboratory testing). In this case, the comparisons made with empirical observations do not provide a legitimate technical basis for the models used.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-84 - USE OF DIFFERENTIAL WEIGHT LOSS TO ESTIMATE VERY LOW CORROSION RATES

1. A statement of the contention itself

SAR Subsection 2.3.6.8.1 and similar subsections state that general corrosion may occur, but DOE describes immersion corrosion testing methods and differential weight loss measurements to predict both general and localized corrosion where corrosion rates are very low and the data are to be extrapolated for thousands of years. The test methods are not sufficient to measure general and localized corrosion to an accuracy level sufficient for extrapolation to predict drip shield performance.

2. A brief summary of the basis for the contention

DOE's use of inherently inaccurate differential weight loss measurements from tests of limited duration, especially where there are very low general corrosion rates, and its failure to measure or report the presence of titanium ions or the possible corrosion inhibition effects of these ions in the solution after exposure, which would more accurately indicate measurable metal loss or indicate inhibiting effects of the Ti++ ions in solution, and use of weight loss measurements for localized (i.e., under deposit, crevice, or pitting) corrosion is inaccurate for general corrosion and fails to estimate the severity of localized corrosion, which could result in breach of a corrosion barrier with very small weight loss.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.114(g) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Measuring weight loss on specimens with extremely low corrosion rates is problematic. In the testing reported in SAR Subsection 2.3.6.8.1 and similar subsections, and as described in ANL-EBS-MD-000004 REV002 ACN 01 "General Corrosion and Localized Corrosion of the Drip Shield" (04/27/2006), LSN# DN2002228104 it was noted that cleaning procedures to remove surface deposits on the test coupon material sometimes resulted in weight gain due to inadequate cleaning. Clearly, weight loss measurement on this basis must also be suspect.

Localized corrosion (i.e., pitting, crevice, and under deposit) tends to cause minimal weight loss even with severe penetration rates. Using weight loss as a means of assessing this type of corrosion is not valid compared to examining surfaces for attack and judging failure based on such evidence. In the example below, the weight loss for the drip shield projected area is compared with the weight loss for full penetration holes of ¼ inch diameter. It would take about 743 ¼ inch full thickness holes to match the weight loss of general corrosion of 0.025 mm (0.001 inch). For a 1-mm corrosion allowance, this translates to nearly 30,000 holes of ¼ inch diameter. A drip shield would not serve its function well with 30,000 ¼ inch diameter holes in it. With the relatively rapid penetration rates due to localized corrosion, the time until penetration can be much less than the time for loss due to general corrosion of 1 mm of surface.

Use of Weight Loss is Very Deceptive for Describing Localized Corrosion

	L	W		Area	
Projected Area of Drip Shield	228	100		22800	sq.in.
Weight of Projected Surface	0.625			2322.75	lbs/area
Weight of 1 mil of surface	0.001			3.7164	lbs/mil

Compare to holes in material

	Dia	sq.in.	depth	Weight
1/4" diameter holes	0.25	0.0491016	0.625	0.0050022

Full Penetration Holes to Match Weigh Loss of 1 mpy 743

Immersion testing with numerous specimens in a single container, without describing solution replenishment procedures, leaves open the possibility that all test results are compromised due to the presence of titanium ion in solution.

Testing on limited air aeration compared to a more positive way to assure oxygen equilibrium with the test solution (like bubbling the gas through the solution), as well as failure to test using nitrogen or pure oxygen aeration to better quantify the limits of aeration effects, leaves open the possibility that all test results are compromised due to the effects of different levels of aeration.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges DOE's use of differential weight loss based on immersion corrosion testing methods used at the Long Term Test Corrosion Facility (LTCTF), as described in SAR Subsection 2.3.6.8.1 and similar subsections**,** and in DOE reference document DN2002228104, to predict both long term general corrosion and localized corrosion, as well as the failure to evaluate the effects of Ti++ ion concentration in the solution and various aeration effects leaves open the possibility that all test results are compromised. Taking such questionable data and extrapolating it for times several orders of magnitude greater than those tested is not a sound or credible engineering approach and affects the basis upon which the dose to the RMEI is predicted. Thus, SAR Subsection 2.3.6.8.1 and related subsections do not comply with 10 C.F.R. § 63.114(g), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-85 - DECLINING CORROSION RATE OVER TIME

1. A statement of the contention itself

SAR Subsection 2.3.6 states that the model implementation for corrosion is considered conservative because the general corrosion rate of metals and alloys is known to decrease with time, but the referenced tests are invalid and therefore this assumption is not applicable.

2. A brief summary of the basis for the contention

The LA relies upon data from tests in closed systems that have subsequently been shown to be invalid because the effects of titanium corrosion product ion (Ti++) in solution were not properly addressed, and therefore, the assumption that corrosion rates decline over time and that the model adopted is conservative in this regard is invalid.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(f) requires any performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. 10 C.F.R. § 63.114(g) further requires any performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE appears to have ignored possible corrosion inhibiting effects of titanium corrosion product ion (Ti++) in solution and of various aeration conditions in its long-term immersion corrosion tests by failing to periodically refresh the test solutions. Thus, the immersion test results reported where a large number of specimens were placed in a modest closed volume of the test solution are highly questionable, particularly where the result is to be extrapolated over thousands of years. The effect of corrosion product titanium ions in solution is not apparent in standard short-term electrochemical tests. Although in early testing in the 1950's it was thought that corrosion rates fell over time, *see* Millaway, E.E. (1965), "Titanium: its Corrosion Behavior and Passivation," MATERIALS AND PROTECTION at 17-21, subsequent research demonstrated the inhibiting effect of the titanium ion, the effects of titanium ion (Ti++) in solution, and of variable aeration on corrosion test results, which have been demonstrated in numerous tests made by laboratories engaged in testing of titanium for corrosion applications. Aeration effects have also been shown to be significant in the results of corrosion tests with titanium. Although DOE purported to examine the effects of aeration, it did not compare aeration using oxygen, air and nitrogen, for example, to better define valid bounds for its data, nor does the aeration method described, air passing over the surface, provide assurance that the aeration conditions were really known or consistent throughout DOE's testing.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's assumption in SAR Subsection 2.3.6 that corrosion rates decrease over time. By ignoring the effects of build-up of titanium ions in their experimental configuration and by inadequately simulating aeration, DOE test results are questionable, particularly given that they are extrapolated over thousands of years, and DOE inappropriately presents the unproven assumption that the rates will decline over time as making the results even more conservative. Thus, SAR Subsection 2.3.6 does not comply with 10 C.F.R. § 63.114(f), which requires any performance assessment used to demonstrate compliance with § 63.113 to provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Nor does SAR Subsection 2.3.6 comply with 10 C.F.R. § 63.114(g), which further requires any performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many

thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-86 - ROLE OF ROCK DUST ON CANISTER SURFACES IN LOCALIZED CORROSION

1. A statement of the contention itself

SAR Subsection 2.3.6.4.4.1 and related subsections, which describe DOE's model for localized corrosion, are grossly incomplete because common and ubiquitous rock dust (siliceous and feldspathic) can form crevices on C-22 and Ti-7 surfaces that are favorable environments for localized corrosion.

2. A brief summary of the basis for the contention

Proposed repository construction and desert-derived ventilation dust and mineral precipitates on the C-22 and Ti-7 surfaces can act as a trapping-cap crevice for acid gases and brines where acid gas will not escape into the tunnel atmosphere, thereby promoting localized corrosion and invalidating DOE's localized corrosion model.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with 10 C.F.R. Part 63 applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the License Application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations to support scientific or factual materials

Geochemically benign dust can form loosely spaced crevices that are favorable physical environments for localized corrosion initiation with acid brines and vapors produced by hydroscopic salt dust and/or unsaturated zone seepage. SAR Subsection 2.3.6.4.4.1 at 2.3.6-46 clearly states:

> Brines produced from dust deposits onto the Alloy 22 waste package outer barrier will not generate a favorable environment for localized corrosion initiation and growth. If brine exists at elevated temperatures (>120˚C), it will be benign, rather than corrosive and initiation of localized corrosion and subsequent penetration of the waste package outer barrier are not expected.

The operating DOE premise is that acid vapors will evolve into the tunnel atmosphere and therefore will not have time to react with critical EBS materials such as the C-22 outer canister barrier. Yet, SAR Subsection 2.3.6.4.3.1.3 at 2.3.6-38 suggests that crevices may form on the waste package below "mineral scales, corrosion products and rocks." The State of Nevada has laboratory evidence (*see* "Experiments Devised to Study Temperature and Geometry Effects of Corrosion of C-22 Alloy" (04/23/2008), LSN# NEV000005235) that supports these statements in SAR Subsection 2.3.6.4.3.1.3, which contradict SAR Subsection 2.3.6.4.4.1. Yet nowhere within the SAR does DOE actually state that dust can form crevices. Furthermore, thermally evolving seepage water may also be trapped under dust, dust combined with rock fall debris, or rock fall debris forming crevices that are therefore fed by low pH brines. These environments are likely to enhance C-22 corrosion, but are not considered in DOE's corrosion models.

SAR Subsection 2.3.5.6 at 2.3.5-142 states that:

> Although deliquescence of salts on the waste package surface is expected to occur, this process has been excluded from TSPA (Section 2.2.1) because the effects of such deliquescence have been determined to be insignificant to performance (Section 2.3.5.5.1).

SAR Subsection 2.3.6.4.4.1 at 2.3.6-40 and 41 indicates that the small quantity of brines at elevated temperature will hinder corrosion initiation and extent. DOE only provides discussions on deliquescent salt dust as acid brine producers, it does not consider the capping and consequently the crevice forming properties of the dust in creating environments that promote corrosion.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.4.4.1 and related subsections, which describe DOE's model for localized corrosion, because they are grossly incomplete because common and ubiquitous rock dust (siliceous and feldspathic) can form crevices on C-22 and Ti-7 surfaces that are favorable environments for localized corrosion. Thus, SAR Subsection 2.3.5.6 does not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must evaluate in detail degradation, deterioration, or alteration processes of engineered barriers, if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to

each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-87 - INTERGRANULAR SCC CORROSION DURING DRY-WET CYCLE

1. <u>A statement of the contention itself</u>

SAR Subsection 2.3.6.5 and similar subsections, which describe stress corrosion cracking (SCC) of the waste package outer barrier, fail to consider SCC initiation as a consequence of dry-wet drip cycling inter-granular corrosion thereby underestimating the environmental causes for C-22 stress corrosion cracking.

2. <u>A brief summary of the basis for the contention</u>

State of Nevada dry-wet drip corrosion experiments at 90-160˚C observed SCC in Alloy C-22 forming at the base of inter-granular corrosion pits with multiple re-nucleation during unsaturated zone water drip and dryout experiments (*see* "Experiments Devised to Study Temperature and Geometry Effects of Corrosion of C-22 Alloy," 2008, LSN# NEV000005235 at 1-17) which contradicts localized corrosion observations in solution immersion studies made by DOE.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with 10 C.F.R. Part 63 applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Cyclic dripping and dryout experiments using unsaturated zone water are reasonable approximations of conditions in the waste emplacement drift environment during thermal peak and cool down periods. Consequently, the State of Nevada ran dryout experiments to simulate waste emplacement environmental conditions for 30-days with temperatures ranging from 90-160˚C using unsaturated zone water and maintaining a high relative humidity in the experimental chambers. Samples of C-22 were exposed both above and below the salt accumulation line. These experiments (NEV000005235 at 1-17) showed that:

1) There were no differences between the corrosion reactions in the vapor and salt submersion portions of the test samples;

2) A significant amount of SCC was observed at the bottom of re-nucleating inter-granular corrosion tunnels;

3) SCC may be more active at lower temperatures.

DOE does not report laboratory data to address any of these issues.

The potential for degradation by corrosion is a primary consideration in waste package performance and for the TSPA as a whole. The natural Yucca Mountain system is dominated by fracture flow in which unsaturated zone water is supplied by infiltration from individual storm events. Thus, fracture flow is cyclic with dryout periods between storm events. It is reasonable to adopt the conceptual model that the proposed repository environment (waste containment drifts) will receive a portion of their seepage as drip and flow cycles with dryout periods. Consequently, it was considered appropriate to develop corrosion experiments to ascertain how the C-22 outer container barrier behaves under these conditions, particularly as DOE has not undertaken such experiments or provided such an analysis.

The State of Nevada has determined that when this environmental mode is studied, SCC was observed at the bottom of re-nucleating inter-granular corrosion tunnels. The State of Nevada consequently finds that DOE has not adequately investigated corrosion of C-22 in the drift environment. Thus, SAR Subsection 2.3.6.5 and similar subsections, which describe stress corrosion cracking (SCC) of the waste package outer barrier, are grossly incomplete.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsection 2.3.6.5 and similar subsections, which describe SCC of the waste package outer barrier, fail to consider SCC initiation as a consequence of dry-wet drip cycling inter-granular corrosion thereby underestimating the environmental causes for C-22 stress corrosion cracking. In consequence, these subsections do not comply with 10 C.F.R. §§ 63.21(c)(3)(ii), 63.21(c)(14), 63.102(h), 63.113, 63.114(f) and 63.115, which require that any performance assessment must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that

are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-88 - THERMODYNAMICS OF COMPLEX DELIQUESCENT SALT REACTIONS DURING C-22 CORROSION

1. A statement of the contention itself

SAR Subsections 2.3.6.4.4.1, 2.3.5.5.4.2.1 and 2.3.5.5.4.3 and similar subsections, which describe hydroscopic dust and seepage environments, fail to consider the formation of a variety of complex hydroscopic natural salts such as tachyhydrite ($CaMg_2Cl_6 \cdot 12H_2O$) and carnallite ($KMgCl_3 \cdot 6H_2O$) that could substantially influence modes and rates of corrosion.

2. A brief summary of the basis for the contention

Complex as well as simple deliquescent salts are expected to form under different environmental conditions in the in-drift environment, yet only some simple salts have been partially characterized in Pizer calculations by DOE; consequently, the potential for corrosion of C22 from salt deliquescence (salt dust as well as seepage) has been poorly studied from the prospective of the environmental conditions that are expected to exist in the waste emplacement drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with 10 C.F.R. Part 63 applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE's thermal-hydrologic-chemical evolution of the four pore water types has considered some aspects of the thermodynamics of simple salt formation within the three brine types produced including brine variations in nitrate/chloride concentrations. Most of DOE's discussions dealing with deliquescent salt production in the proposed repository are confined to dust. Seepage evaporation on C-22 surfaces has been discussed in terms of brine production, and the nitrate/chloride ratio of brine production; but not in terms of common complex deliquescent salts that are likely to form. Possibly, this is due to the difficulty in dealing with complex salts using Pitzer calculations. Each mineral salt has its own stability field. Therefore, when only a few non-bounding simple salts are considered, the environmental picture of potential deliquescent salt authigenesis through the thermal-hydrologic-chemical history of the potential repository is inadequate, incomplete and misleading.

SAR Subsection 2.3.5.3.3.5.2 discusses ambient pore-water compositional trends and mineral assemblages without considering complex salts and considers only calcite as a simple salt. No salt data other than those for calcite are presented for fracture flow unsaturated zone percolation conditions. Once the unsaturated zone water has entered the waste emplacement drifts, only simple salt formation is considered. As a minimum, natural mineral salt assemblages should have been considered when developing the near-field geochemical model. Tachyhydrite, for example, has been recognized forming in laboratory experiments with Yucca Mountain unsaturated zone water.

Tachyhydrite occurs naturally in salt deposits such as in the Carlsbad Potash District, Eddy County, New Mexico and in Brefeld, Tartun, Stassfurt Potash deposit, Saxony-Anhalt, Germany. Associated salts found with tachyhydrite in natural deposits include: halite ($NaCl$), sylvite (KCl), kieserite ($MgSO_4 \cdot H_2O$), calcite ($CaCO_3$), anhydrite ($CaSO_4$), sinjarite ($CaCl_2 \cdot 2H_2O$), antarcticite ($CaCl_2 \cdot 6H_2O$), bischofite ($MgCl_2 \cdot 6H_2O$), kainite ($MgSO_4 \cdot KCl \cdot 3H2O$), and carnallite ($KMgCl_3 \cdot 6H_2O$).

SAR Subsection 2.3.5.6 discusses the chemical and physical features of the emplacement drifts and indicates that dust deliquescence has been excluded from consideration. The in-drift precipitates/salts model (SAR Subsection 2.3.5.5.3) has been evaluated through sensitivity analyses and comparison of model results with site-specific data from independent laboratory experiments, natural analogues and compilations of salt solubility measurements. The seepage evaporation analysis and results (SAR Subsection 2.3.5.5.3.2) discusses the following salts: halite (NaCl), calcite or aragonite ($CaCO_3$), and sylvite (KCl). The remaining discussion is confined to the composition of brines but not the relationship(s) between the brines and the authigenic salts. There is an implicit assumption by DOE that the nitrate/chloride ratio of any brine present is independent of the final deliquescent salt formed, instead of recognizing that the complex salt formed, or the group of simple hydroscopic salts formed in a particular area of the C-22 surface, determines the nitrate/chloride ratio. This ratio is fixed by the relationship between the brine and the hydroscopic salt assemblage. If, as DOE assumes, the nitrate/chloride ratio can have an important role in influencing the mode and rate of corrosion, it is imperative to have some real basis for understanding the types and amounts of authigenic salts present. These data are missing from the DOE analysis.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsections 2.3.6.4.4.1, 2.3.5.5.4.2.1 and 2.3.5.5.4.3 and similar subsections, which describe hydroscopic dust and seepage environments, fail to consider the formation of a variety of complex hydroscopic natural salts such as tachyhydrite ($CaMg_2Cl_6 \cdot 12H_2O$) and carnallite

($KMgCl_3 \cdot 6H_2O$) that could substantially influence modes and rates of corrosion. In consequence, these subsections do not comply with 10 C.F.R. §§ 63.21(c)(3)(ii), 63.21(c)(14), 63.102(h), 63.113, 63.114(f) and 63.115, which requires that any performance assessment must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-89 - INHIBITION OF C-22 CORROSION BY HIGH NITRATE TO CHLORIDE RATIO

1. A statement of the contention itself

SAR Subsections 2.3.5.3.2.2.1 (unsaturated zone pore water chemistry), 2.3.6.4.4.1 (abstracted model for localized corrosion), 2.3.6.4.2 (data and data uncertainty), and similar subsections, which discuss the nitrate-to-chloride ratio with respect to C-22 corrosion inhibition, fail to describe any experimental conditions that represent the waste emplacement drift environment, and fail to consider low pH evaporative conditions that do represent that environment; consequently, the corrosion models utilized for C-22 are inappropriate.

2. A brief summary of the basis for the contention

Simulated C-22 test waters (SAW, SCW, BSW, SDW, J-13, and other compositions) utilized in DOE immersion corrosion experiments are not representative of Yucca Mountain unsaturated zone fracture flow groundwater in either chemical composition or mode of delivery (which will be drip or flow) to the C-22 waste package; consequently, DOE nitrate-to-chloride ratio corrosion inhibition data have not addressed the environmental conditions to which C-22 will be exposed and the results obtained from those experiments are not supported by State of Nevada unsaturated zone drip experiments (*see* "Experiments Devised to Study Temperature and Geometry Effects of Corrosion of C-22 Alloy" (04/23/2008), LSN# NEV000005235 at 1-17) that do represent the appropriate environment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with 10 C.F.R. Part 63 applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed

individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Nitrate/chloride ratios as characterized by DOE in their 34 pore-water samples may not be representative of seepage waters because:

1) Nitrate can be separated from chloride due to differences in vapor pressure;
2) Nitrate salts can be separated from chloride salts during gravity flow evaporation on the surface of C-22 due to their differences in solubility;
3) Nitrates can be, in part, removed from pre-seepage waters by bacterial action in the incubator zone above the proposed repository emplacement drifts;
4) Nitrate and chloride concentrations determined in the 34 pore-water samples have not been adequately correlated to nitrate and chloride concentrations in fracture flow unsaturated zone water, which is the type of water that will seep into the emplacement drifts.

The nitrate/chloride ratio may not determine oxygen repair at the C-22 passivating film oxide-coating surface under environmental brine conditions where the pH is very low. All of the DOE experimentation concerning the effect of the nitrate/chloride ratio on the passivating film layer, which protects the metal surface from corrosion, have been in bath experiments that do not have low pH characteristics (in contrast to the concentrated brines that form on evaporation in the relevant conditions) and that do not approximate the conditions that will prevail in the waste emplacement drifts. Most of DOE's bath aqueous compositions have both Cl^- and NO_3^- in solution, and as long as there is more repair function than corrosion function, the passive film layer will remain intact. If the $\text{chloride}_{\text{aqueous}}$ values increase in concentration, or the $\text{nitrate}_{\text{aqueous}}$ values drop in concentration (to some extent SO_4^{--} to SO_3^{--} conversion would also have a similar effect) the rate of repair of the passivating film will be affected. There are no experimental data obtained or discussed by DOE to show that C-22 is offered corrosion protection by high nitrate concentrations in very low pH brine environments, especially at elevated repository temperatures. The passivating film cannot even repair itself under low pH nitric acid conditions without the presence of chloride, although the rate of corrosion for nitric acid is much less than for hydrochloric acid. When the two acids are mixed, as in the DOE immersion experiments, the apparent lower rate of corrosion with the increasing presence of nitric acid is not due to inhibition as much as it is due to a mixing ratio of about 1:200 for the nitrate: chloride corrosion rate ratio. A bath environment, as utilized by DOE, maintains several characteristics that are inappropriate to the waste emplacement drift environment:

1) The nitrate/chloride ratio used for experimentation remains constant for that experiment and is based upon the simulated pore-water composition chosen;
2) There is no dry out;
3) The reacting liquid temperature is relatively low;
4) Concentrations of corrosive species are low.

It is totally unrealistic to assume that the canister will be submerged in the emplacement drifts and therefore laboratory bath experiments only approximate non-brine ponding conditions that do not represent the emplacement drift environment.

In summary, SAR Subsections 2.3.5.3.2.2.1 (vadose pore water chemistry), 2.3.6.4.4.1 (abstracted model for localized corrosion), and 2.3.6.4.2 (data and data uncertainty) relate to a combined model of nitrate/chloride corrosion inhibition that, although well supported by immersion experiments, does not apply to waste emplacement drift conditions. Experiments and models relevant to evaluating SCC and localized corrosion of C-22 must address:

1) Hydrogeochemistry, based upon a valid mode of transport and seepage introduction into the waste emplacement drift environment from an aqueous source;

2) Salt dust geochemistry based upon salt source compositions, brine chemistry, dust deposit morphology, and dust delivery to the EBS metal surfaces;

3) The dynamics of temperature, humidity and atmospheric pressure;

4) Mode of contact with the C-22 surface that is consistent with the geologic-thermal-physical conditions that exist in the waste emplacement drift environment.

DOE has not provided an adequate link between the characteristics of the environment in the waste emplacement drifts and their laboratory analysis/model support for proposed reactions in that environment. During salt-cap-crevice corrosion starting with simulated, unconcentrated unsaturated zone water that then undergoes evaporative concentration, massive pitting and channeling occurs in C-22 when the pH is low, even when the nitrate/chloride ratio is greater than 1. In reality, when nitrate is present, NO_3^- reacts to NO_2^-, and the corrosion potential is raised into the passive zone as long as the pH is high enough so that the chemistry at the passive layer favors layer stability. This is a condition that is easy to maintain under the DOE bath experimentation protocol. This, however, is not representative of the waste emplacement drift environment, and consequently, the DOE nitrate/chloride ratio inhibition philosophy does not apply in the conditions of practical relevance.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsections 2.3.5.3.2.2.1 (unsaturated zone pore water chemistry), 2.3.6.4.4.1 (abstracted model for localized corrosion), 2.3.6.4.2 (data and data uncertainty) and similar subsections, which discuss the nitrate to chloride ratio with respect to C-22 corrosion inhibition, fail to describe any experimental conditions that represent the waste emplacement drift environment, and fail to consider low pH evaporative conditions that do represent that environment. This means that the corrosion models utilized for C-22 are inappropriate, and in consequence, that these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-90 - EFFECTS OF ROCK BOLT ON C-22 AND Ti-7 CORROSION REACTIONS

1. A statement of the contention itself

SAR Subsections 1.3.4.4, 2.3.6, and similar subsections, which describe the use, design, and corrosion of Super Swellex-type stainless steel rock bolts in the ground support system and the corrosion of C-22, fail to consider that debris from rock bolt corrosion will accumulate on the drip shield and on the C-22 canister and will be deleterious to both EBS-barrier components.

2. A brief summary of the basis for the contention

HSLA-steel dust from the corrosion of the Super Swellex rock bolts will be deleterious to both the C-22 and Ti-7 EBS alloys because of the presence of reactive deleterious trace elements and because of crevices formed in the debris fields that will accumulate on the C-22 and Ti-7 surfaces.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

There is adequate DOE literature that supports the need for rock bolts to maintain Yucca Mountain underground drift structural integrity. In addition, there is a sufficient volume of DOE literature, *e.g.*, "FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific

Bases and Analyses, TDR-MGR-MD-000007 REV 00G" (06/30/2001), LSN# DN2002071183 at 240-244 and Section 4.3.3, at 4-25-32, to indicate that these rock bolts will act as conduits for seepage and will assist in distributing the heat flux into the surrounding near-field tuff. Finally, as a consequence of the Drift Scale Heater Test (*see* "Scientific Notebook for Draft Scale Test Activities, SN-SNL-SCI-034-V1" (04/03/2007), LSN# DN2002409568 at 1-96) the "red" rust deposits that formed on the surface of the heater were derived from the degradation of a rock bolt, suggesting that the claim to a 100-year lifetime for the rock bolts is likely to be an overestimate, or at least cannot be relied upon for safety assessment purposes without additional evidence.

Even with limited degradation, one can expect to find in the emplacement drifts an accumulation of dust and coarser debris that have originated from rock bolts. Some of this debris will accumulate on the surfaces of the Ti-7 drip shield and C-22 outer barrier of the waste canister. These deposits will provide two types of environmental effects that can enhance corrosion: (i) a physical debris field that acts as crevices; and (ii) a supplier of deleterious trace elements with the capacity to accelerate SCC. These two effects are discussed separately below.

Physical Debris Field:

The physical debris field formed by rock bolt (and other ground support materials) corrosion may be more extensive than rock dust derived from construction activity and/or desert dust derived from ventilation, at least for some significant percentage of drip shields and canisters. There have been no DOE studies on this topic that are reported in the license application (other than references to the Drift Scale Heater Test). DOE does recognize the potential of rock fall and salt deposits as mechanisms that create crevices (*see* SAR Subsection 2.3.6.4.3.1.3). Crevices promote SCC and localized corrosion. Dust and debris fields provide physical environments for the entrapment of vapors, some of which are acidic and can promote chloride brine corrosion of both Ti-7 and C-22. Rock bolt degradation occurs when liquids or vapors come into contact with the rock bolt (as, for example, in the Drift-Scale Heater Test). The rock bolt seepage conduit and the debris field from rock bolt corrosion are located spatially together, providing relatively ideal conditions for C-22 and Ti-7 corrosion.

Deleterious Trace Elements:

Two trace elements (sulfur and lead) are of particular concern with respect to their potential concentrations in Super Swellex-type stainless steel rock bolts. Both of these elements are known to cause corrosion failure in C-22. The sulfur concentrations are generally less than 0.05% and the lead concentrations are presumed to be on the average in low ppm values. State of Nevada experiments have shown deleterious lead concentrations cause SCC in C-22. Specifically, very small total amounts of lead are sufficient, because these are sequestered at the C-22 surface and accumulate to substantial concentrations in short periods of time. Both lead and sulfur will be mobilized from debris dust at the surface of C-22 as a consequence of oxyhydroxide sorption reactions and as a consequence of being spatially associated with dripping seepage fluids and brines due to overhead rock bolts. DOE has not provided trace element concentration data in bounding ranges (ppt to %) for EBS materials that form an integral part of the ground-support system. Consequently, the corrosion of ground support materials (most of which have short design lifetimes) provides an unknown and untested mixture of ions to the in-drift environment. The deleterious components in this mixture may cause both SCC and localized corrosion of C-22 and Ti-7. DOE has not addressed this topic in any sections in the license application.

In summary, there is a paucity of detailed (ppt) trace element information available for ground support materials that will be in the waste emplacement drift environment. DOE has not studied the mobilization of trace elements from the corrosion of these short-lived EBS materials. Nor are there DOE studies concerning the deleterious affects of these corrosion products on the lifetime of C-22 or Ti-7. This is of concern, since both the physical and chemical characteristics of rock bolt decay may promote the corrosion of C-22 and Ti-7.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsections 1.3.4.4, 2.3.6 and similar subsections, which describe the use, design, and corrosion of Super Swellex-type stainless steel rock bolts in the ground support system and the corrosion of C-22, fail to consider that debris from rock bolt corrosion will accumulate on the drip shield and on the C-22 canister and will be deleterious to both EBS-barrier components. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether

acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-91 - REPRESENTATIVENESS OF C-22 AND Ti-7 CORROSION TESTING METHODS

1. A statement of the contention itself

SAR Subsection 2.3.6.1.2 and similar subsections, which deal with corrosion test environments and in-drift chemical environments, fail to utilize testing methods and hydrogeochemical compositions that capture the conditions and chemistries to which C-22 and Ti-7 are expected to be exposed in the emplacement drifts of the proposed repository.

2. A brief summary of the basis for the contention

DOE has utilized aqueous compositions that are not representative of the waste emplacement drift environment and has used those compositions in inappropriate immersion tests employing temperatures at the low end of the range of interest to estimate corrosion of C-22 and Ti-7 in the environment of the waste emplacement drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE's corrosion program for Ti-7 and C-22 has ignored key physical and chemical characteristics of the environment in the waste emplacement drifts. Aspects that remain un-modeled and un-treated with respect to corrosion in the DOE License Application are as follows:

1) Rubble environments;
2) Dust environments;
3) Salt-crust environments;
4) Coupled salt-crust and rubble and dust environments;
5) Coupled deliquescent and seepage environments;
6) Seepage conditions that favor wall rock temperatures above 100˚C;
7) Drip seepage environments;
8) Dryout and drip seepage environments;
9) Pre-evaporated seepage water environments;
10) Microbial environments with respect microbially induced corrosion (MIC) for all EBS materials and, in particular, Ti-7 and C-22;
11) Microbial/fungal environments with respect to the hydrogeochemistry of unsaturated zone water;
12) Deleterious trace element environments.

In fact, much of the DOE corrosion program as portrayed in SAR Subsection 2.3.6 and similar subsections is based on experimental strategy that is not related to the dynamic properties of the waste emplacement drift environment.

The basic objective in assessing the behavior of C-22, for example, in the emplacement drifts is to adequately determine the lifetime of the C-22 layer around packages and thereby assess the performance of the EBS. The experimental apparatus should, therefore, adequately model or mimic the repository environment. In doing so, one may argue for validity by using a well-corroborated theory based upon sound calibrated laboratory models that are shown to be valid representations of the environment of interest. This has not been achieved by DOE. Specifically, it is not possible to exclude the twelve items listed above from consideration and to focus solely on bath experimentation, as there is no correlation between the laboratory bath environment and conditions under which C-22 and Ti-7 are proposed for use.

To justify claims about the correspondence between the Yucca Mountain environment and the laboratory models, DOE would have to show that the bath model environment provides the same environmental-chemical-thermal-spatial conditions as would arise due to the omitted un-modeled environmental parameters. This has not been done. Furthermore, DOE recognizes that its existing work is inappropriate and/or inadequate as it has proposed a long-term corrosion-testing program (*see* "Long-Term Corrosion Testing Plan (Supersedes SAND2007-7027 Dated 10/2007)" (08/01/2008), LSN# DEN001600862, which considers many of the items that are listed above that are totally absent from the discussion in SAR Subsection 2.3.6. Furthermore, even in relation to the existing experiments, there is little evidence to show that bounding unsaturated zone water compositions have been captured within the DOE laboratory testing program or will be captured in the future, as there is no compelling evidence to show that pore-water is similar to fracture flow water.

In summary, SAR Subsections 2.3.5 and 2.3.6 demonstrate that the corrosion modeling undertaken by DOE has been based upon unsupported claims that their laboratory models are valid representations of the waste emplacement drift environment. It is suggested, for example, that the nitrate/chloride ratio will provide adequate protection to the passivating film on C-22 because experimentation in simulated water bath conditions provide compelling evidence to this effect. Yet, it is known that this ratio does not exert the control that DOE claims under the conditions of low pH that commonly occur during unsaturated zone dripping and evaporation. By not addressing the wide range of expected environmental conditions, the DOE model for corrosion behavior is unsupported and unjustified, and cannot be used to underpin arguments relating to drip shield and waste package lifetime. In consequence, no credence can be placed in DOE estimates of radionuclide releases from the EBS or assessed radiation doses to the RMEI.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsection 2.3.6.1.2 and similar subsections, which deal with corrosion test environments and in-drift chemical environments, fail to utilize testing methods and hydrogeochemical compositions that capture the conditions and chemistries to which C-22 and Ti-7 are expected to be exposed in the emplacement drifts of the proposed repository. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

NEV-SAFETY-92 - IMPACTS OF FLUORIDE DUE TO BREACH OF HLW CONTAINERS

1. A statement of the contention itself

SAR Subsection 2.3.5 and similar subsections, which deal with the in-drift physical and chemical environment, fail to take account of releases of chemicals by early degraded EBS components in overall calculations of radionuclide containment.

2. A brief summary of the basis for the contention

Fluoride concentrations that can evolve from a single breached HLW glass waste package can result in an increase in fluoride ion concentrations in the emplacement drift, thereby potentially increasing the corrosion of both the Ti-7 drip shield and other waste containers.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Fluoride concentrations that can evolve from a single early breached HLW glass waste form (*see* SAR Subsection 2.3.7.10.3) can increase the fluoride ion concentration in the emplacement drift, especially in evaporated brines. DOE does not take into account the effects of early failure of EBS components in the calculation of overall corrosion and radionuclide release within the emplacement drift. Early failure of one or more HLW glass canisters can affect, for example, the fluoride ion concentrations in aqueous and vapor phases within the emplacement drift. Elevated fluoride concentrations in late phase brine formation, beyond the anticipated fluoride concentrations from fracture flow seepage, can become aggressive towards Ti-7 drip shields and the C-22 outer layer of the remaining canisters, as well as to the C-22 outer layer of the breached canister, and can affect the dissolution of the in-package waste form(s) resulting in greater rates of radionuclide evolution from the in-drift environment. The fluoride issue is only one of many geochemical issues where the failure of one EBS component needs to be coupled to the geochemical behavior of all or most other EBS components in the in-drift environment. DOE fails to take account of these couplings, thereby underestimating the geochemical complexity of the in-drift and near field environments and the potential for enhanced rates of release of radionuclides to the accessible environment. Thus, the discussions of the in-drift chemical environment in SAR Subsection 2.3.5 and similar subsections are insufficient and incomplete, and do not rigorously treat the geochemical system as a complex of coupled processes.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.5 and similar subsections, which deal with the in-drift physical and chemical environment, fail to address coupled chemical processes in which one EBS failed component may affect the stability of another EBS component. In this regard, for example, the breach of one canister of HLW glass can increase fluoride ion concentrations in the in-drift environment. This addition can affect the stability of other EBS components such as the drip shield and other canisters, thereby affecting the evolution rates of radionuclides from containment. These are clearly coupled processes. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-93 - NATURAL LEAD REACTIONS ON C-22

1. A statement of the contention itself

SAR Subsection 2.3.6 and similar subsections, which deal with waste package and drip shield corrosion, fail to account for deleterious effects of natural lead remobilized and/or newly mineralized as coronadite [$Pb(Mn^{4+}Mn^{2+})_8O_{16}$] and/or lead carbonates in unsaturated zone fracture system seepage onto C-22 surfaces.

2. A brief summary of the basis for the contention

Coronadite, a lead manganese oxide, found in fracture coatings in Yucca Mountain, is generally a hydrothermal vein or hot springs mineral. Coronadite can be newly formed or remobilized in Yucca Mountain during the thermal period. If this mineral or lead carbonate, which is also located in fractures, come into contact with C-22, they have the potential to cause catastrophic SCC failure.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Coronadite (*see* "LA-11787-MS, Manganese-Oxide Minerals in Factures of the Crater Flat Tuff in Drill Core USW G-4, Yucca Mountain, Nevada" (07/01/1990), LSN# DEN000861516 at 2-22), a manganese lead oxide fracture-coating mineral from Yucca

Mountain, has been well characterized in the DOE program. This mineral is part of the cryptomelane group and is commonly found in association with hollandite and pyrolusite. The lead concentration is generally over 25 percent. DOE's program (*id.*) suggests that there is an almost complete gradation between hollandite (Ba) and cryptomelane (K) and between hollandite and coronadite (Pb). These minerals were most likely formed from hydrothermal activity in the volcanic tuffs some time after eruption. Although in the present-day Yucca Mountain most of the lead-loaded manganese oxides are located below the repository, it is possible that with elevated repository temperatures in the near field and with the normally high degree of oxidation in the transporting fluids, new mineralization of similar manganese oxides will occur.

The appearance of lead-manganese oxides at Yucca Mountain also suggests the potential of lead-bearing colloid transport to and from the near field. If coronadite were to enter or form in the emplacement drifts and were to be deposited on the surface of C-22 outer container barrier, there is reasonable evidence that the lead would react with the C-22 to cause corrosion. *See* Pulvirenti, A.L., Needham, K.M., Adel-Hadadi, M.A., Marks, C.R., Gorman, J.A., and Barkatt, A., "Effects of Lead, Mercury, and Reduced Sulfur Species on the Corrosion of Alloy 22 in Concentrated Groundwaters as a Function of pH and Temperature," Scientific Basis for Nuclear Waste Management XXV, Symposium held 11/26-29/2001, Boston, Massachusetts (2002), LSN# NEV000002753.

Lead-containing carbonate is also present in fractures and faults in Yucca Mountain (*e.g.*, the Ghost Dance Fault). Much of the lead is assumed to be aerosol that has been trapped in soil carbonates. The lead concentrations are in low ppm range. As carbonate dust in the waste emplacement drift environment is derived from ventilation, these trace lead concentrations have the potential to cause deleterious reactions in C-22 if the dust is deposited on the C-22 surface. The lead in the dust can also be remobilized by acid leaching of the carbonate.

The potential for these deleterious reactions to occur should have been investigated by DOE. If lead minerals were not present in Yucca Mountain then the concern would be minimal. However, lead is naturally present in Yucca Mountain, both below and above the repository horizon. The source of lead in the fracture systems above the repository is the carbonate coating fracture deposits and dust particles in the soil zone. This dust has the capacity to be introduced to the in-drift environment during the ventilation period. The lead in the manganese oxides is normally observed below the repository horizon, but could be remobilized and redeposited at the repository horizon during hydrothermal activity associated with the repository.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.6 and similar subsections, which deal with waste package and drip shield corrosion, fail to account for the deleterious effects of natural lead remobilized and/or newly mineralized as coronadite [$Pb(Mn^{4+}Mn^{2+})_8O_{16}$] and/or other authigenic minerals, such as calcite containing trace lead concentrations. These lead-containing minerals have the capacity to be deleterious to C-22. In consequence, SAR Subsection 2.3.6 and similar subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-94 - SIGNIFICANCE OF MINERAL CRUSTS IN C-22 CORROSION

1. A statement of the contention itself

SAR Subsections 2.3.6.4, 2.6.3.5 and similar subsections, which deal with localized and SCC waste package corrosion, fail to give adequate consideration to the role of mineral precipitates in forming crevices and facilitating corrosion on C-22 surfaces.

2. A brief summary of the basis for the contention

Authigenic salt precipitates from evaporation of seepage waters can form a trapping cap crevice that sequesters acid brines and vapors providing microenvironments on the C-22 surface that promote corrosion.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. §

63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

As seepage water evaporates, mineral precipitates will begin to form based upon ion solubilities and concentrations. Generally, the early authigenic minerals will be calcite, gypsum (selenite) and opal. These will be followed by chloride and nitrate salts once concentrated brines are created. Some of the chloride and nitrate salts are hydroscopic. Salt scales and frothy caps (sponge-like) will be dominated by calcite and gypsum with minor concentrations of opal. The chlorides and nitrate salts will generally form in the "pockets," where brines have accumulated during the later stages of evaporation. Some of the chloride and nitrate brines will become trapped against the C-22 surface. These authigenic evaporite deposits are considered by DOE as scale-like crevices (*see* SAR Subsection 2.3.6.4.3.1.3).

SAR Subsection 2.3.6.4.3.1.3 at 2.3.6-38 suggests that crevices may form on the waste package below "scales, corrosion products and rocks." This is the only statement in SAR Subsection 2.3.6 that deals with the issue of scale or salt precipitation as a crevice former. DOE states that it does not expect the entire waste package surface to be subjected to crevice-like conditions. While salt scale-like deposits formed on the C-22 surface will act as crevices, the methods of treatment of these crevices with respect to C-22 corrosion by DOE is flawed. DOE provides no direct experimental evidence of the behavior of these crevices with respect to C-22 corrosion, and all DOE experimentation with respect to crevice and localized corrosion is based upon immersion studies. Consequently, the crevice repassivation potential that DOE utilizes is not justified or appropriate for use in radiological impact assessment as none of the experimentation offered to support the DOE model is based on the conditions expected to prevail on waste package surfaces. The salt-based scale or evaporite deposits formed on the C-22 surface will initiate during the formation of brines. This evaporation can go to complete dryout and can be rewetted upon initiation of new seepage. It is unlikely that these salt deposits will form only under continuous wet conditions. Thus, their structure and the compositions of included brines will be very variable and heterogeneous.

DOE's model treats corrosion propagation as occurring at a rate that does not depend on the conditions of chemical exposure. This is unrealistic because in some of the conditions that are likely to occur the corrosion will likely stifle; whereas, in other conditions such as salt crusting, pitting can lead to channeling that can then lead to SCC with very rapid failure. The use of a constant rate is inappropriate and has the potential to underestimate the degree of penetration of the waste package that will occur in regions of enhanced corrosion. Thus, the localized corrosion propagation model (*see* SAR Subsection 2.3.6.4.3.2) is not applicable to the environment in the waste emplacement drifts nor does it provide an appropriate conceptual model for the corrosion behavior of C-22. DOE also utilized a time-dependent propagation rate model in which the rate slows with time. Again, this model is not supported by any experimentation relevant to the environments likely to be encountered in the waste emplacement drifts, and is extremely unlikely to accurately describe C-22 corrosion under a salt cap.

The localized corrosion propagation rates (12.7 to 1,270μm/yr) in SAR Subsection 2.3.6.4.3.2.1 are not based upon corrosion rates obtained from relevant environment-specific experimentation. Rather, they are apparently based upon a DOE literature review of experiments undertaken for different purposes and in other contexts, and thus are not directly applicable to estimating the actual corrosion rates that would occur under a salt cap on a waste package surface.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.6 and other similar subsections fail to provide adequate consideration of the role of mineral precipitates in forming crevices and the accompanying corrosion on C-22 surfaces. Although there is obvious agreement that crevices form by this method, there is no DOE experimentation offered to assess the rates of corrosion or the extent of corrosion under these conditions. Furthermore, DOE adopts an inappropriate and unsupported conceptual model of the processes involved, and does not have relevant experimental support for the corrosion rates used in that model. There are strong scientific arguments that this mode of corrosion will be extremely significant, but its extent and significance cannot be assessed on the basis of the information provided and models developed by DOE. In consequence, SAR Subsection 2.3.6 and other similar subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-95 - PEAK THERMAL PERIOD SEEPAGE AND CORROSION

1. A statement of the contention itself

SAR Subsections 2.3.3, 2.3.5 and 2.3.6 and similar subsections dealing with water seepage and corrosion, fail to account for corrosion of C-22 and Ti-7 during the thermal period.

2. A brief summary of the basis for the contention

Seepage into the emplacement drifts is possible during the thermal period and brines and deliquescent salts formed during this seepage have the capacity to cause C-22 and Ti-7 corrosion.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural

barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE assumes that seepage into the emplacement drifts will not occur during the thermal period (*see* SAR Subsection 2.3.5.4.1.1.3), and that only after the wall rock temperatures drop below 100˚C can seepage occur. This assumption is made even though perched water zones may form (*see* SAR Subsections 2.3.2.1, 2.3.2.2.2.4, and 2.3.2.4.1.2.4.4), supported by capillary barriers at faults, leading to water accumulation above the containment drifts. Breakdown of such barriers could lead to non-equilibrium seepage events that are not limited by a wall rock temperature of 100˚C. In this context, SAR Subsection 2.3.3.3.1 at 2.3.3-58 states:

> The heating of near-field rock to the boiling temperature of water the resulting flow perturbation affects the potential for seepage. Condensed water forms a zone of slightly elevated water saturation in fractures above the dryout zone. Water from this zone may be mobilized to flow rapidly down towards the drift. However, seepage would only be possible if both the vaporization barrier in the boiling zone and the capillary barrier at the drift ceiling would be breached. Results from the thermal-hydrologic seepage model demonstrate that this scenario is not expected.

In the above DOE scenario, the head of water available in large fractures would control non-equilibrium seepage because a high hydraulic head would overcome both of the conceptual barriers (vaporization and capillary). The result obtained in this scenario depends greatly upon the parameter values used to represent the fracture system, and DOE has considered only conditions in which non-equilibrium seepage does not occur. However, it is possible to generate seepage into the containment drifts during the thermal period in conceptual models and for a range of realistic parameter values that have not been addressed by DOE.

Authigenic salt formation during thermal period seepage will consist of an abundance of carbonates, opal, anhydrite-selenite, chloride salts, nitrate salts, and complex salts. In addition, transition metal ion oxides and oxyhydroxides may co-precipitate with the above salts due to the rapid decomposition of EBS components exposed to elevated temperatures and oxidized fluids. The mineral association in the in-drift environment may approximate to hot springs deposits, hydrothermal deposits and evaporative lake and marine deposits, depending upon the degree of rock and EBS dissolution and decomposition, the thermal characteristics of the zone of deposition, and the quantities of fluids available. The geochemistry of these authigenic salts may include trace elements that are deleterious to C-22. Hydroscopic salt formation under mineral crusts may contribute to corrosion failure of C-22 and Ti-7. DOE incorrectly ignores all corrosive reactions on EBS materials during the thermal period.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

Seepage into the emplacement drifts is possible during the thermal period and brines and deliquescent salts formed during this seepage have the capacity to cause C-22 and Ti-7 corrosion. SAR Subsections 2.3.3, 2.3.5 and 2.3.6 and similar subsections dealing with water seepage and corrosion, fail to account for corrosion during the thermal period. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include

the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-96 - SALT PRODUCTION AND C-22 CORROSION DUE TO HEAT-PIPE CONDITIONS

1. A statement of the contention itself

SAR Subsections 2.3.2.2.2.6, and 2.3.6 and similar subsections, which describe unsaturated zone heat-pipe thermal processes and corrosion, give a description of those processes that is inadequate for safety assessment, because it fails to recognize that convection cells can produce extensive deposits of evaporites that can result in a "pressure cooker" effect, can affect water delivery to the drip shield and waste package, and can provide large quantities of deliquescent salts to the in-drift environment affecting the lifetime calculations for C-22 and Ti-7.

2. A brief summary of the basis for the contention

The heat-pipe conditions that are anticipated by DOE can create evaporite salt plugging, change the flow, hydrogeochemistry and moisture characteristics of the in-drift environment (pressure cooker effect) and can create corrosive microenvironments that will affect the lifetimes of Ti-7 and C-22 EBS components.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Heat-pipe conditions (large- or small-scale) develop as liquid-vapor counter flow where the vapor flux moves away from the emplacement drift and unsaturated zone fracture flow moves towards the drift as percolation. DOE anticipates that these processes will occur (*see* SAR Subsection 2.3.2.2.6). They can cause extensive evaporite production, create large-scale to small-scale ponded water in fracture and fault systems, can form a pressure cooker in the drift, and can trap forced percolation in the emplacement drifts. Heat-pipes can, even if they exist for only short periods of tens to hundreds of years, create hydrogeochemical conditions that accelerate the corrosion of C-22 and Ti-7. The eventual failure of salt plugs as a consequence of overburden weight (head and/or internal pressure) can create unsaturated zone flow conditions that far exceed the percolation fluxes and volumes into the emplacement drifts that have been calculated by DOE. Salt production within the drifts will also be substantially different under heat-pipe conditions. The hydrogeochemistry of unsaturated zone water affected by heat-pipe conditions has the potential to be very different from the water chemistry used by DOE to test the corrosion of C-22. Overall, heat-pipe conditions can greatly affect the hydrogeology and the hydrogeochemistry of the emplacement drifts and thereby create conditions that greatly affect the stability and corrosion resistance of C-22 and Ti-7. The License Application fails to provide an adequate assessment of the response of C-22 and Ti-7 to heat-pipe conditions.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsections 2.3.6, 2.3.2.2.2.6, and similar subsections, which describe the corrosion of C-22 and Ti-7 and the formation of heat-pipes, fail to recognize that convection cells formed during DOE anticipated heat-pipe conditions can produce extensive deposits of evaporites that can affect water delivery to the drip shield and waste package and can provide large quantities of deliquescent salts to the in-drift environment affecting the lifetime calculations of C-22 and Ti-7. These processes are of major potential importance in determining the lifetime of EBS components and are not addressed in the license application. In consequence, the license application does not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's

other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-97 - CREVICE CORROSION ON C-22 DUE TO DRIP SHIELD CORROSION DEBRIS

1. A statement of the contention itself

SAR Subsection 2.3.6 and similar subsections, which describe the DOE model for drip shield corrosion, fail to recognize that the degradation of the drip shield will cause a debris field that collects on the surface of the waste canisters and that this debris field can accelerate C-22 corrosion resulting in degraded performance of the EBS.

2. A brief summary of the basis for the contention

SAR Subsections 2.2 and 2.3.6 screened out localized corrosion, SCC of the drip shield and corrosion due to deliquescence on the basis of experiments that do not mimic in-drift conditions, and as a consequence, DOE has over estimated the performance of the drip shield and under estimated the extent of Ti-7 and Ti-29 debris fields that will have deleterious effects on the stability of C-22.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsections 2.2, 2.3.5, and 2.3.7 describe the drip shield and its reported value to the engineered barrier system. However, various FEPs have been inappropriately excluded from consideration:

FEP 2.1.03.02.0B Stress corrosion cracking (SCC) of drip shield
FEP 2.1.03.03.0B Localized corrosion of drip shield
FEP 2.1.06.07.0A Chemical effects at EBS component interfaces-Drip Shield
FEP 2.1.09.28.0B Localized corrosion on drip shield surface due to deliquescence

All of these exclusions and the associated credit taken for drip shield performance are based upon experimentation that either utilizes immersion in J-13 saturated zone water, or immersion in waters of simulated compositions such as BSW-12 (basic saturated water) or contain a variety of salts.

The drip shield is actually named on the basis that it is designed to divert the dripping of unsaturated zone seepage water. It was not named "the immersion shield" for very good reasons. DOE experimentation needed to be performed on the basis of the projected environment in the emplacement drifts. It is anticipated that dripping conditions on the "drip shield" will result in the following environmental characteristics that are not taken into account in the DOE analysis:

1) Drips will be cyclic with dryout, and during dryout salt solutions containing chloride and fluorides will concentrate into brines on the surface of the drip shield. Saturated or under-saturated salt solutions in baths do not at all approximate to these conditions, as they do not promote the development of concentrated brines and are not accurate scale models of the in-drift environment.
2) Dripping of unsaturated zone fracture flow water will be caught between drip shield sections. These areas will form crevices and corrosion in these crevices will follow normal SCC behavior, again generated by chlorides and fluorides.
3) Once corrosion breaches the upper surface of a drip shield, corrosion will be maintained on both the upper and lower surfaces. The rate and volume

of corrosion cannot be calculated based upon consideration of the upper surface alone.

4) Drip Shield corrosion will take place under evaporative salt deposits, where deliquescent salts have accumulated with very strong acid brines.

5) Drip Shield corrosion will take place under rock and rock bolt dust deposits that act as crevice formers.

As it is anticipated that the degradation of the drip shield will be more rapid and extensive than assumed by DOE, consideration needs to be given to the debris field formed by this drip shield failure. Once the drip shield fails, percolation will reach the C-22 surface. The debris field that forms from the degradation of the drip shield will contribute to the corrosion of the waste canister. The drip shield debris field, similar to but more extensive than the debris field formed by the degradation of rock bolts, provides a cap-like cover that forms crevices on the surface of the C-22. Dripping unsaturated zone water vapors and brines are trapped within these crevices and corresponding corrosion occurs. This alternative model of coupled drip shield and waste canister degradation is relevant to early and later failures of the EBS and would have significant deleterious effects on the overall performance of the disposal system.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.6 and similar subsections, which describe the DOE model for drip shield corrosion, do not recognize that the degradation of the drip shield will cause a debris field that collects on the surface of the waste canisters and that the presence of that debris field can accelerate C-22 corrosion. Further, DOE has poorly characterized the corrosion of Ti-7 and Ti-29 because they have not utilized either fracture flow water compositions in the unsaturated zone, nor have they employed experimental means that mimic the delivery of that water to the drip shield itself. In consequence, SAR Subsection 2.3.6 and similar subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-98 - RATE OF DRIP SHIELD INTERCONNECTION CORROSION

1. A statement of the contention itself

SAR Subsections 1.3.4, Figures 1.3.4-14 and 1.3.4-15, and similar subsections which describe the drip shield, fail to recognize that the connector plate and plate sections, due to the interlocking design, form crevices that have the potential to provide a locus for SCC driven by the concentrations of chloride and fluoride in unsaturated zone waters.

2. A brief summary of the basis for the contention

The drip shield design includes crevices and consequently there is the potential for SCC in these crevices, yet DOE has improperly excluded the SCC FEP from consideration.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. §

63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The drip shield is designed to prevent separation upon rock fall and to function as a drip diverter during unsaturated zone seepage. The drip shield is made of individual sections that are proposed to be fitted together in the in-drift environment. This design (*see* SAR Figures 1.3.4-14 and 15 at 1.3.4-89 and 91) forms crevices at the intersections between drip shield plates. These crevices are spatially situated such that they are likely to intercept drips and have the capability to provide environments in which SCC would occur. DOE has excluded SCC on the basis of immersion experiments, but has not experimented with crevices in drip-dryout conditions using fracture flow unsaturated zone water. DOE's design is potentially susceptible to degradation by SCC and the DOE testing program has not addressed the possibility of SCC under the conditions that would exist in the waste emplacement drifts. This omission means that the rate and degree of degradation of the EBS is underestimated, with implications for radionuclide releases and assessed doses to the reasonably maximally exposed individual.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 1.3.4, Figures 1.3.4-14 and 1.3.4-15, and similar subsections that describe the drip shield, fail to recognize that the interlocking section design forms crevices that have the potential to provide locations for SCC driven by chloride and fluoride present in percolating unsaturated zone water. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-99 - BORIC ACID PRODUCTION FROM HLW DISSOLUTION

1. A statement of the contention itself

SAR Subsection 2.3.7 (FEP 2.1.09.02.0A) and similar subsections, which describe chemical interactions with corrosion products, fail to recognize the potential corrosive role of boric acid formed from the dissolution of HLW glass waste.

2. A brief summary of the basis for the contention

The potential for boric acid to form in the in-drift environment as a function of the degradation of the HLW glass waste form has not been considered, despite the large concentration of boron in the glass and the history of boric acid caused corrosion in the nuclear industry.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Dissolved boron will be released into the in-drift environment during the dissolution of HLW glass waste form. The role of boron in evaporative environments has not been favorable to the nuclear industry (*see, e.g.*, the problems encountered at the Davis Besse nuclear reactor). The role of boron in the in-drift environment is unknown because there are no reported DOE studies dealing with this topic. The quantity of boron that can be released from one breached canister may be quite sufficient to affect the corrosion of other canisters encapsulated in the same drift – thus a domino effect can incur. DOE has not provided an adequate analysis of the potential role of EBS corrosion products that might enhance dissolution rates of C-22 and Ti-7. Thus, the license application is deficient in this area of analysis and underestimates potential releases of radionuclides from the EBS and radiation doses to the reasonably maximally exposed individual.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.7 (FEP 2.1.09.02.0A) and similar subsections that describe chemical interactions with corrosion products, fail to recognize the potential role of boric acid formed from the dissolution of HLW glass waste. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that

are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-100 - GROUND SUPPORT COMPONENTS AND IN-DRIFT MODELING

1. A statement of the contention itself

SAR Subsection 1.3.4.4 describes the ground support system as including Bernold-type sheets that have the potential to degrade during heat-up, the peak thermal period, and cool down generating oxyhydroxide debris fields on drip shields (comprising dust, scale and granular debris) and waste canisters (comprising oxyhydroxide dust and scale). These debris fields will result in the formation of mineralized crevices that can trap acid vapors formed by deliquescent salts derived from dust and percolation, thereby increasing corrosion rates and adversely affecting the containment properties of the system. However, SAR Subsection 2.3.5 and similar subsections, which describe the in-drift chemical environment models, fail to take account of the ground support components in defining the chemical composition of the in-drift environment.

2. A brief summary of the basis for the contention

Iron and manganese oxyhydroxide dust can sorb transition metals among other ions thereby changing the local micro-surface chemistry of drip shield and canister surfaces, and can physically promote the formation of crevices that can harbor acid vapors thereby affecting the corrosion potential of the critical EBS components such as the C-22 canister surface.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed

individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.4 describes the ground support system, which includes in its design 3-mm thick Bernold-type stainless steel that provides rock confinement for the upper two-thirds of the drift surface – approximately a 240 degree arc around the drift periphery and above the invert structure. *See also* SAR Subsection 1.3.4.4.1 and Figures 1.3.4-4 and 1.3.4-7. This ground support system has the potential to degrade during heat-up, the peak thermal period, and cool down generating oxyhydroxide debris fields on drip shields (comprising dust, scale and granular debris) and waste canisters (comprising oxyhydroxide dust and scale), resulting in the formation of mineralized crevices that can trap acid vapors formed by deliquescent salts derived from dust and percolation.

DOE has not provided an analysis of the deleterious chemical effects of the degradation of perforated stainless steel sheets (*see* SAR Figures 1.3.4-4 and 1.3.4-7) on the drip shield and waste canister. In addition to the deleterious effects of transition metal sorption of ground support system oxyhydroxide degradation products on C-22 (*e.g.*, lead and cadmium), there is the effect of the physical debris field produced directly or indirectly by ground support corrosion. Direct production of corroded debris involves the deposition of oxyhydroxide mineralized debris onto the drip shield or, if the drip shield is compromised, onto the canister surfaces. Indirect production involves the deposition of the debris field on the drip shield and then only when there is drip shield failure this material then drops onto the canister surface. In either case, the debris field provides a cap that accepts liquids, traps liquids and vapors, and potentially contains deleterious metallic species such as lead derived from the degraded EBS materials as well as the perturbed natural environment. These conditions can promote the corrosion of critical EBS materials such as the drip shield and waste canister.

Although there are no reported trace element analyses for the ground support system components that DOE plans to use, the materials that might be provided to the in-drift system due to the degradation of the Bernold-type stainless steel will probably be:

- percent values of Fe, Cr, Ni, Mo, Al; and
- values in the order of a tenth of a percent to ppm of Mn, P, Co, Cu, Ti, Sb, Pb, Sn, As, Cd.

The mobilization of some of these elements to the surfaces of Ti-7 and C-22 may pose a serious problem especially when those surfaces exhibit crevices.

Although SAR Subsection 2.3.5 purports to describe the chemical environment in the emplacement drifts, what is missing is any information concerning the contribution of the ground support system, including the Bernold-type stainless steel sheets that will be used, in that chemical environment.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.5 and similar subsections, which describe the in-drift chemical environment models, fail to include ground support components in the chemical composition of the in-drift environment and therefore these components have been omitted from consideration in all of the corrosion experiments undertaken by DOE. All of these data are missing from the license application, yet trace elements that might be deleterious to C-22 will be present in the in-drift environment. They have the ability to promote radionuclide transport by colloidal action, and have the capacity to affect corrosion reactions in debris dust on C-22 surfaces and crevices. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-101 - SULFUR ACCUMULATION AT THE METAL-PASSIVE FILM INTERFACE

1. A statement of the contention itself

SAR Subsection 2.3.6.3 (and subsections therein), which addresses the general corrosion of the waste package outer barrier, fails to consider the possibility of sulfur accumulation at the metal-passive film interface during slow passive corrosion, which could lead to an increased rate of uniform corrosion.

2. A brief summary of the basis for the contention

Based on relatively short-term laboratory tests as compared to the required repository life, DOE assumes that there will be a very slow corrosion rate of the C22 canister (which DOE assumes to be constant); however, the conceptual model does not take account (and thus DOE has not evaluated the possibility) of the accumulation of trace elements in the alloy (notably sulfur) at the metal-passive film interface, which produce very high corrosion rates for nickel once the sulfur coverage reaches about one monolayer.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of the measures used to support the models used to provide the information in paragraph (c)(9). 10 C.F.R. § 63.114(e) (part of Subpart E) requires a performance assessment used to demonstrate compliance with Section 63.113 to provide the technical basis for either inclusion or exclusion of specific features, events and processes in the performance assessment. 10 C.F.R. § 63.114(b) requires the performance assessment to provide the technical basis for parameter ranges and paragraph (f) requires the technical basis for exclusion of degradation processes of engineered barriers. This contention alleges non-compliance with these regulatory provisions.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

It is well-known within the corrosion community that the corrosion rate of nickel is markedly increased by the generation of a layer of sulfur at the metal-passive film interface by a process known as "anodic segregation." *See* Marcus, P. (2002), Corrosion Mechanisms in Theory and Practice, ISBN 0824706668, 9780824706661 (CRC Press) at 293. Similar effects have been found for NiFe and Alloy 600. *See* Marcus, P., "Long Term Extrapolation of Passive Behavior" (Proceedings of the International Workshop on Long-Term Extrapolation of Passive Behavior, 19-20 July 2001, Arlington, Virginia), LSN# NEV000003496 at 55-60. It appears that an interfacial sulfur concentration approaching one monolayer ($\sim 40 \times 10^{-9}$ g cm^{-2}) is required for this effect to lead to breakdown of passivity. For the specification maximum sulfur concentration in C22 (0.02%), and assuming that all of the sulfur remains at the metal-passive film interface, this will require the dissolution of 230 nm of the alloy (i.e., 40×10^{-9} g cm^{-2} /($0.02\times10^{-2}\times8.69$ g cm^{-3})).

DOE concludes that the maximum uniform corrosion rate will be 24 nm/yr at a 95% confidence limit, *see* SAR Subsection 2.3.6.3.2.1, at 2.3.6-20, which implies that this effect will take on the order of 10 years. However, this approach results in the minimum possible time until the breakdown in passivity (since it assumes maximum sulfur concentration, maximum corrosion and no loss of sulfur) and the time required to reach the critical sulfur concentration could be hundreds of years. This phenomenon has not been tested in the 5-year experimental data used to support the SAR. This effect is mentioned in passing in DOE reference document "General Corrosion and Localized Corrosion of the Waste Package Outer Barrier" (Sandia National Laboratories, Las Vegas, Nevada 2007), LSN# DN2002460404 at 6-14, where it is suggested that molybdenum tends to counter the deleterious effect of sulfur. However, no direct experimental evidence is given to support this argument in the particular conditions of the repository, and no attempt is made to quantify the possible increase in corrosion rate that might be produced by the presence of sulfur.

Some work has been performed on the possible increase in corrosion rate that might be produced by the presence of sulfur. *See* Jones, R.H., Baer, D.R., Windisch, Jr., C.F., and Rebak, R.B., "Corrosion Enhanced Enrichment of Sulfur and Implications for Alloy 22," CORROSION/2006, PAPER 06621, San Diego, 12-16 March 2006. Importantly, the authors concluded, at 15:

> The presence of S at 2% under conditions of this experiment may contribute to localized corrosion, however, due to the limited data reflecting this finding, future work needs to address this possibility further. This is especially true considering the small amount of corrosion obtained in these tests resulted still resulted [sic] in a measurable increase in the surface S concentration. Given a great amount of corrosion, over a longer period of time, it is important to determine if great S

> enrichment occurs (i.e., up to 100% or 1 monolayer) and what affect this might have on the corrosion performance of Alloy 22.

A more recent review of this process has also concluded, "Among these potential processes, anodic sulfur segregation process might be detrimental and requires further experimental evaluation." *See* Jung, H., Mintz, T., Dunn, D.S., Pensado, O., and Ahn, T., "A Review of the Long-Term Persistence of the Passive Film on Alloy 22 in Potential Yucca Mountain Repository Environments," LSN# NRC000029382 at xiii. In the absence of such work, the specification of Alloy 22 is unsafe.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE statements contained in SAR Subsections 2.3.6.3 (and subsections therein), which in turn relies on DOE reference document DN2002460404, which addresses the general corrosion of the waste package outer barrier, because they fail to consider the possibility of sulfur accumulation at the metal-passive film interface during slow passive corrosion. As a result, SAR Subsection 2.3.6.3 (and subsections therein) is both materially incomplete and inaccurate because DOE has not evaluated the possibility of an increased rate of uniform corrosion that would occur once the sulfur coverage reaches about one monolayer at the metal-passive film interface. Therefore, SAR Subsection 2.3.6.3 (and subsections therein) do not comply with the requirements of 10 C.F.R. §§ 63.21(c)(9), 63.21(c)(15), 63.113, and 63.114(e), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-102 - SULFUR ACCUMULATION AND LOCALIZED CORROSION

1. A statement of the contention itself

SAR Subsection 2.3.6.4 and similar subsections fail to consider the possibility of sulfur accumulation at the metal-passive film interface during slow passive corrosion, which could lead to an increased susceptibility to localized corrosion.

2. A brief summary of the basis for the contention

DOE did not take account of the accumulation of sulfur from the alloy at the metal passive film interface – a process that will produce very high localized corrosion rates for nickel once the sulfur coverage reaches about one monolayer – because DOE relied on laboratory tests that were of insufficient duration to observe this process.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.113 requires a performance assessment that evaluates multiple barriers, including both natural and engineered barriers. 10 C.F.R. § 63.115(c) requires demonstration of compliance with 10 C.F.R. § 63.113 and includes a technical basis describing

the capability of those barriers to isolate waste. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

It is known that sulfur, whether sourced from within the metal (*e.g.*, as MnS inclusions) or derived from reduced sulfur species (*e.g.*, sulfide or thiosulfate ions) in the environment, has a strong tendency to enhance the susceptibility of corrosion resistant alloys to localized corrosion. *See* Marcus, P. (2002), "Corrosion Mechanisms in Theory and Practice," ISBN 0824706668, 9780824706661 (CRC Press) at 293. Thus it is known that the rate of corrosion of nickel is markedly increased by the generation of a layer of sulfur at the metal-passive film interface by a process known as "anodic segregation," whereby sulfur in the alloy collects at the alloy-passive film interface as the metallic components of the alloy are oxidized into the passive film. Similar effects have been found for NiFe and Alloy 600. *See* "Long Term Extrapolation of Passive Behavior, Proceedings of the International Workshop on Long-Term Extrapolation of Passive Behavior, Arlington, Virginia, USA; United States Nuclear Waste Technical Review Board" (07/19-20/2001), LSN# NEV000003496 at 55-60. It appears that an interfacial sulfur concentration approaching one monolayer ($\sim 40 \times 10^{-9}$ g cm^{-2}) is required for this effect to lead to breakdown of passivity. For the specification maximum sulfur concentration in Alloy 22 (0.02%), and assuming that all of the sulfur remains at the metal-passive film interface, this will require the dissolution of [40×10^{-9} g cm^{-2} /($0.02\times10^{-2}\times8.69$ g cm^{-3})] = 230 nm of the alloy. For the maximum uniform corrosion rate proposed by DOE (24 nm/y at a 95% confidence limit) (*see* SAR Subsection 2.3.6.3.2.1 at 2.3.6-20), this implies that the development of this effect will take of the order of 10 years. However, this is the minimum possible time (since it assumes maximum sulfur concentration, maximum corrosion and no loss of sulfur) and the time required to reach the critical sulfur concentration could be hundreds of years. Furthermore, it is known that sulfur aids the initiation of localized corrosion, and more importantly, such initiation does not appear to be subject to a critical potential requirement (i.e. it can happen at any potential). *See* NEV000003496 at 55-60. Thus, this process could lead to the initiation of localized corrosion several hundred years into the life of the repository, in environmental conditions that are predicted to be benign and at rates that are faster than predicted by the models incorporated in the SAR, which is consequently non-conservative. This effect is mentioned in passing in the supporting documentation (*see* "General Corrosion and Localized Corrosion of Waste Package Outer Barrier," ANL-EBS-MD-000003 Rev 03 (07/25/2007), LSN# DN2002460404 at 6-14), where it is suggested that molybdenum tends to counter the deleterious effect of sulfur. However, no direct experimental evidence is given to support this argument in the particular conditions of the repository, and no attempt is made to quantify the possible increase in corrosion rate that might be produced by this effect. Some work has been performed on this possibility, *see* Jones, R.H., Baer, D.R., Windisch Jr., C.F., and Rebak, R.B. (11/18/2005), "Corrosion

Enhanced Enrichment of Sulfur and Implications for Alloy 22," CORROSION/2006, PAPER 06621 (San Diego, California, March 12-16, 2006), and at 15, the authors concluded:

> The presence of S at 2 at. % under conditions of this experiment may contribute to localized corrosion, however, due to the limited data reflecting this finding, future work needs to address this possibility further. This is especially true considering the small amount of corrosion obtained in these tests resulted still resulted (sic) in a measurable increase in the surface S concentration. Given a great amount of corrosion, over a longer period of time, it is important to determine if great S enrichment occurs (i.e. up to 100% or 1 monolayer) and what affect this might have on the corrosion performance of Alloy 22.

A recent review concluded that "[a]mong these potential processes, anodic sulfur segregation process might be detrimental and requires further experimental evaluation." "A Review of the Long-Term Persistence of the Passive Film on Alloy 22 in Potential Yucca Mountain Repository Environments" (10/31/2007), LSN# NRC000029382 at v. In the absence of such work, the suitability of Alloy 22 for disposal has not been demonstrated..

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.4 and similar subsections because they fail to consider the possibility of sulfur accumulation at the metal-passive film interface during slow passive corrosion, which could lead to an increased susceptibility to localized corrosion. As a result, DOE has failed to comply with 10 C.F.R. § 63.114(f) which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and further requires that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-103 - SULFUR ACCUMULATION AND STRESS CORROSION INITIATION

1. A statement of the contention itself

SAR Subsection 2.3.6.5 and similar subsections fail to consider the possibility of sulfur accumulation at the metal-passive film interface and at grain boundaries in the alloy during a combination of slow passive corrosion and exposure at relatively high temperature, which would create a strong susceptibility to stress corrosion crack initiation.

2. A brief summary of the basis for the contention

Based on unduly short term laboratory tests, stress corrosion cracking initiation of the Alloy 22 canister is modeled to require a threshold stress of 90 to 105% of the yield stress. However, sulfur accumulation at the alloy-passive film interface, coupled with sulfur segregation to grain boundaries, may be expected to facilitate crack initiation, leading to a lower threshold stress.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.113 requires a performance assessment that evaluates multiple barriers, including both natural and engineered barriers. 10 C.F.R. § 63.115(c) requires demonstration of compliance with 10 C.F.R. § 63.113 and includes a technical basis describing the capability of those barriers to isolate waste. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

It is known that sulfur, whether sourced from within the metal, *e.g.*, as MnS inclusions (*see* Kain, V., Sengupta, P., De, P.K., Banerjee, S. (2005), "Case Reviews on the Effect of Microstructure on the Corrosion Behavior of Austenitic Alloys for Processing and Storage of Nuclear Waste," METALLURGICAL AND MATERIALS TRANSACTIONS A., Vol. 36A, No. 5 at 1075-1084), or derived from reduced sulfur species, *e.g.*, sulfide or thiosulfate ions, in the environment, has a strong tendency to enhance the susceptibility of corrosion resistant alloys to stress corrosion crack initiation. *See* Lee, E.H., Kim, K.M., Kim, U.C. (03/2007), "Effects of reduced sulfur on the corrosion behavior of Alloy 600 in high-temperature water," MATERIALS SCIENCE AND ENGINEERING A., Vol. 449-451 at 330-333. For example, thiosulfate solutions have been used as a medium in which stress corrosion cracking of stainless steels is facilitated. *See* Aballe, A., Newman, R.C., and Cottis, R.A. (2003), "Electrochemical noise study of stress corrosion cracking of sensitized 304H in thiosulfate" (CORROSION/2003 PAPER 03403, San Diego, CA, March 16-20) at 9. Sulfur is expected to accumulate under the passive film as sulfur in the alloy is left behind during slow passive corrosion (*see* Marcus, P. (2002), "Corrosion Mechanisms in Theory and Practice," ISBN 0824706668, 9780824706661 (CRC Press) at 293), and it can be expected to surface diffuse to grain boundaries during the higher temperature phase of repository life. An interfacial sulfur concentration approaching one monolayer ($\sim 40 \times 10^{-9}$ g cm^{-2}) will be achieved in about 10 years, assuming the specification maximum sulfur concentration in Alloy 22 (0.02%), that all of the sulfur remains at the metal-passive film interface, and that the passive corrosion rate is the maximum proposed by DOE (24 nm/y at a 95% confidence limit). *See* SAR Subsection 2.3.6.3.2.1 at 2.3.6-20. However, this is the minimum possible time (since it assumes maximum sulfur concentration, maximum corrosion and no loss of sulfur) and the time required to reach a critical sulfur concentration could be hundreds of years. This process could lead to the initiation of stress corrosion cracking several hundred years into the life of the repository, in environmental conditions that are predicted to be benign by the models incorporated in the SAR, which is consequently non-conservative. The influence of sulfur on localized corrosion is mentioned in passing in DOE's supporting documentation (*see* "General Corrosion and Localized Corrosion of Waste Package Outer Barrier," ANL-EBS-MD-000003 Rev 0 (07/25/2007), LSN# DN2002460404 at 6-14), where it is suggested that molybdenum tends to counter the deleterious effect of sulfur. However, no direct experimental evidence is given to support this argument in the particular conditions of the repository, and no attempt is made to quantify the possible influence of this effect on stress corrosion crack initiation. A recent review concluded, "Among these potential processes, anodic sulfur segregation process might be detrimental and requires further experimental evaluation." *See* Jung, H., Mintz, T., Dunn, D.S., Pensado, O., and Ahn, T. (10/31/2007), "A Review of the Long-Term Persistence of the Passive Film on Alloy 22 in Potential Yucca Mountain Repository Environments," LSN# NRC000029382 at v. In the absence of such work, the suitability of Alloy 22 for disposal has not been demonstrated.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.3.6.5 and similar subsections because they fail to consider the possibility of sulfur accumulation at the metal-passive film interface and at grain boundaries in the alloy during a combination of slow passive corrosion and exposure at relatively high temperature, which would create a strong susceptibility to stress corrosion crack initiation. As a result, DOE has failed to comply with 10 C.F.R. § 63.114(f) which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and further requires that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether

acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-104 - SULFUR ACCUMULATION AND STRESS CORROSION PROPAGATION

1. A statement of the contention itself

SAR Subsection 2.3.6.5 and similar subsections fail to consider the possibility of sulfur accumulation at the metal-passive film interface, and at grain boundaries in the alloy during a combination of slow passive corrosion and exposure at relatively high temperature, which could lead to an increased susceptibility to stress corrosion crack propagation.

2. A brief summary of the basis for the contention

Based on unduly short term laboratory tests, stress corrosion cracking propagation of the Alloy 22 canister is modeled to occur only when a threshold stress intensity factor, $K_{ISCC,}$ is exceeded, with the crack growth rate being described by a film rupture – repassivation model. However, sulfur accumulation as the alloy-passive film interface, coupled with sulfur segregation to grain boundaries, may be expected to lead to a reduced value of K_{ISCC} and more rapid crack growth.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.113 requires a performance assessment that evaluates multiple barriers, including both natural and engineered barriers. 10 C.F.R. § 63.115(c) requires demonstration of compliance with 10 C.F.R. § 63.113 and includes a technical basis describing the capability of those barriers to isolate waste. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

It is known that sulfur, whether sourced from within the metal, *e.g.*, as MnS inclusions (*see* Kain, V., Sengupta, P., De, P.K., Banerjee, S. (2005), "Case Reviews on the Effect of Microstructure on the Corrosion Behavior of Austenitic Alloys for Processing and Storage of Nuclear Waste," METALLURGICAL AND MATERIALS TRANSACTIONS A., Vol. 36A, No. 5 at 1075-1084), or derived from reduced sulfur species, *e.g.*, sulfide or thiosulfate ions, in the environment, has a strong tendency to enhance the susceptibility of corrosion resistant alloys to stress corrosion crack initiation. *See* Lee, E.H., Kim, K.M., Kim, U.C. (03/2007), "Effects of reduced sulfur on the corrosion behavior of Alloy 600 in high-temperature water," MATERIALS

SCIENCE AND ENGINEERING A., Vol. 449-451 at 330-333. For example, thiosulfate solutions have been used as a medium in which stress corrosion cracking of stainless steels is facilitated. *See* Aballe, A., Newman, R.C., and Cottis, R.A., "Electrochemical noise study of stress corrosion cracking of sensitized 304H in thiosulfate" (CORROSION/2003 PAPER 03403, San Diego, CA, March 16-20, 2003) at 9. Sulfur is expected to accumulate under the passive film as sulfur in the alloy is left behind during slow passive corrosion (*see* Marcus, P. (2002), "Corrosion Mechanisms in Theory and Practice," ISBN 0824706668, 9780824706661 (CRC Press) at 293), and it can be expected to surface diffuse to grain boundaries during the higher temperature phase of repository life. An interfacial sulfur concentration approaching one monolayer ($\sim 40 \times 10^{-9}$ g cm^{-2}) will be achieved in about 10 years, assuming the specification maximum sulfur concentration in Alloy 22 (0.02%), that all of the sulfur remains at the metal-passive film interface, and that the passive corrosion rate is the maximum proposed by DOE (24 nm/y at a 95% confidence limit). *See* SAR Subsection 2.3.6.3.2.1 at 2.3.6-20. However, this is the minimum possible time (since it assumes maximum sulfur concentration, maximum corrosion and no loss of sulfur) and the time required to reach a critical sulfur concentration could be hundreds of years. As well as being formed on the passive external surface, sulfur deposits can be expected to be produced within stress corrosion cracks, and to remain at or around the crack tip. Thus this process could lead to enhanced propagation of stress corrosion cracks several hundred years into the life of the repository, in environmental conditions that are predicted to be benign by the models incorporated in the SAR, which is consequently non-conservative. The influence of sulfur on localized corrosion is mentioned in passing in DOE's supporting documentation (*see* "General Corrosion and Localized Corrosion of Waste Package Outer Barrier," ANL-EBS-MD-000003 Rev 0 (07/25/2007), LSN# DN2002460404 at 6-14), where it is suggested that molybdenum tends to counter the deleterious effect of sulfur. However, no direct experimental evidence is given to support this argument in the particular conditions of the repository, and no attempt is made to quantify the possible influence of this effect on stress corrosion crack initiation. A recent review concluded, "Among these potential processes, anodic sulfur segregation process might be detrimental and requires further experimental evaluation." *See* Jung, H., Mintz, T., Dunn, D.S., Pensado, O., and Ahn, T. (10/31/2007), "A Review of the Long-Term Persistence of the Passive Film on Alloy 22 in Potential Yucca Mountain Repository Environments," LSN# NRC000029382 at v. In the absence of such work, the suitability of Alloy 22 for disposal has not been demonstrated.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.5 and similar subsections because they fail to consider the possibility of sulfur accumulation at the metal-passive film interface, and at grain boundaries in the alloy during a combination of slow passive corrosion and exposure at relatively high temperature, which could lead to an increased susceptibility to stress corrosion crack propagation. As a result, DOE has failed to comply with 10 C.F.R. § 63.114(f) which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and further requires that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-105 - DRIP SHIELD CORROSION ENVIRONMENT

1. A statement of the contention itself

SAR Subsection 2.3.6.8 and similar subsections, fail to provide a realistic model of the corrosion behavior of the drip shield because they are based on inappropriate test conditions.

2. A brief summary of the basis for the contention

SAR Subsection 2.3.6.8, which describes the model of drip shield corrosion, is based entirely on tests performed in bulk liquid environments, whereas actual exposure conditions will involve water dripping onto the drip shield where it will be evaporated under the influence of the elevated temperature leading to significantly more aggressive conditions, and hence worse performance, than that predicted in the SAR.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The corrosion tests on which the SAR is based exclusively use bulk liquid environments in isothermal conditions. The real exposure will involve cooler liquids dripping onto a relatively hot metal surface and evaporating. This leads to a number of differences that are known to modify the severity of the corrosion conditions. Specifically, as the liquid evaporates and the salts concentrate, solids precipitate, leading to changes in the liquid composition including significant pH changes. The resultant thin film provides very rapid oxygen transport, while the near-solid salt residue may produce a very aggressive chemistry. Neither of these effects can be achieved using bulk liquid test solutions.

Corrosion by dripping salt solutions, in the particular context of SCC (though there is no doubt that the conditions are also particularly severe for other forms of corrosion), has been examined in the "drop evaporation test" (*see* ISO Standard ISO 15324:2008, "Corrosion of metals and alloys - Evaluation of stress corrosion cracking by the drop evaporation test," ISBN 978 0 580 60538 3), which has been shown to provide rather severe test conditions for stainless alloys exposed to chloride solutions. Work performed by IMR on behalf of the State of Nevada has demonstrated rapid corrosion of Alloy 22 under drop evaporation conditions. *See* "Final Results for C22 Corrosion Test" (04/16/2008), LSN# NEV000005219 at 1-67; and "Effects of Concentrated Hydrochloric and Nitric Aces and NaF on the Corrosion of C-22 Alloy at 25 and 90°C; a Model for Rapid Penetration of C-22" (12/30/1995), LSN# NEV000004183 at 1-114. Similar tests were proposed in 2004 (*see* "Environmental Effects on Corrosion Properties of Alloy 22" (11/10/2004), LSN# DN2002246302), but are not referenced in the predictive models of localized corrosion or SCC used in the SAR.

In the absence of tests under more realistic conditions, and based on the evidence of rapid localized corrosion under some drop evaporation conditions, the model of corrosion performance of the drip shield is unreliable. It has the potential to underestimate the degree to which packages will be penetrated by corrosion and to over-estimate the time required for such penetration. In consequence, it has the potential to result in significant under-estimates of dose to the reasonably maximally exposed individual.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.8 and similar subsections, which fail to provide a realistic model of the corrosion behavior of the drip shield because they are based on inappropriate test conditions. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include

the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-106 - WASTE CONTAINER CORROSION ENVIRONMENT

1. A statement of the contention itself

SAR Subsection 2.3.6.3 and similar subsections fail to provide a realistic model of the corrosion behavior of the canister because they are based on inappropriate test conditions.

2. A brief summary of the basis for the contention

SAR Subsections 2.3.6.3 through 2.3.6.5, which describe the model of canister corrosion and SCC, are based entirely on tests performed in bulk liquid environments, whereas actual exposure conditions will involve water dripping onto the canister where it will be evaporated under the influence of the elevated temperature leading to significantly more aggressive conditions, and hence worse performance, than that predicted in the SAR.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The corrosion tests on which the predictive models presented in SAR Subsections 2.3.6.3 through 2.3.6.5 are based exclusively use bulk liquid environments in isothermal conditions. The real exposure will predominantly involve cooler liquids dripping onto a relatively hot metal surface and evaporating. This leads to a number of differences that are known to modify the severity of the corrosion conditions. As the liquid evaporates and the salts concentrate, solids precipitate, leading to changes in the liquid composition including significant pH changes. The resultant thin film provides very rapid oxygen transport, while the near-solid salt residue typically produces a very aggressive chemistry; neither of these effects can be achieved using bulk liquid test solutions.

Corrosion by dripping salt solutions has been examined, in the particular context of SCC (though there is no doubt that the conditions are also particularly severe for other forms of corrosion), in the "drop evaporation test" (*see* ISO Standard ISO 15324:2008, "Corrosion of metals and alloys - Evaluation of stress corrosion cracking by the drop evaporation test," ISBN 978 0 580 60538 3), which has been shown to provide severe test conditions for stainless alloys exposed to chloride solutions. Such tests were proposed in 2004 (*see* "Environmental Effects on Corrosion Properties of Alloy 22" (11/10/2004), LSN# DN2002246302), but are not referenced in the predictive models of localized corrosion or SCC used in the SAR.

Cyclic unsaturated zone water dripping and dryout experiments are reasonable approximations of conditions in the waste emplacement environment during thermal peak and cool down periods. Consequently, the State of Nevada ran dryout experiments in attempts to simulate waste emplacement environmental conditions for 30-days with temperatures ranging from 90-160˚C using unsaturated zone water and maintaining a high relative humidity in the experimental chambers. Samples of C-22 were exposed to both above and below the salt accumulation line. Results from these experiments ("C-22 Corrosion in Dripped Pore Water. Final Report for Phase II A & B" (2008), LSN# NEV000005216 at 1-17 and "Experiments Devised to Studying Temperature and Geometry Effect of Corrosion of C-22 Alloy, Final Report for Phase II C & D" (2008), LSN# NEV000005235 at 1-17) suggest that:

- Significant localized corrosion was observed in the form of intergranular corrosion tunnels.

- There were no differences between the corrosion reactions in the vapor and salt submersion portions of the test samples.
- A significant amount of SCC was observed at the bottom of re-nucleating intergranular corrosion tunnels.

In the absence of tests under more realistic conditions, and based on the evidence of rapid localized corrosion and SCC under drop evaporation conditions, the proposal to rely so heavily on the integrity of the Alloy 22 canister is unreliable.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.3 and similar subsections which fail to provide a realistic model of the corrosion behavior of the canister because they are based on inappropriate test conditions. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether

acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-107 - ELECTROCHEMICAL REDUCTION OF NITRATE

1. A statement of the contention itself

SAR Subsection 2.3.6.4.3.1.1 and similar subsections, which assert that nitrate is an inhibitor of corrosion, fail to take account of the loss of nitrate by electrochemical reaction.

2. A brief summary of the basis for the contention

The model of localized corrosion of Alloy 22 developed in SAR Subsection 2.3.6.4 implies that nitrate is inhibitive by virtue of raising the repassivation potential, quantified in SAR Subsection 2.3.6.4.3.1.1, Eq. 2.3.6-6, at 2.3.6-34; however, this approach takes no account of the electrochemical reduction of nitrate as a cathodic reaction during the passive corrosion process, which will lead to depletion of nitrate in thin-film deposits, leading to more severe localized corrosion than predicted.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and

Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The model of localized corrosion of Alloy 22 presented in SAR Subsection 2.3.6.4 is strongly influenced by the role of nitrate. The nitrate has two effects: (i) it acts as an inhibitor of passive film breakdown, raising the repassivation potential; and (ii) it acts as an oxidizing agent, raising the open-circuit potential. The second of these effects (and possibly also the first) is accompanied by the consumption of nitrate by electrochemical reaction. The reaction is slow, both because of the slow kinetics of passive corrosion of Alloy 22, and because the inherent kinetics of nitrate reduction are slow (but the observation that nitrate raises the corrosion potential confirms that nitrate must be reacting), and the change in nitrate concentration in the bulk immersion tests on which the SAR is based will be negligible.

However, in more realistic thin liquid films resulting from seepage or salt deliquescence, the quantity of nitrate available is very much less and very long reaction times are available. In contrast to nitrate, chloride is essentially a catalyst for the localized corrosion process, and is not consumed by reaction. Consequently as the nitrate becomes depleted the chloride to nitrate ratio will increase, leading to very much more aggressive solutions. Furthermore, it also seems likely that seepage will replenish nitrate in some locations (*e.g.*, points at which drops fall onto the canister or drip shield), but not others (*e.g.* regions surrounding the points at which drops fall). In this situation the high nitrate regions will lead to a relatively positive corrosion potential, while the nitrate-depleted regions will have a less positive repassivation potential, seriously eroding the potential difference between the corrosion potential and the repassivation potential on which the localized corrosion model is based. In consequence the model of localized corrosion presented in the SAR is unreliable.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.4.3.1.1 and similar subsections which assert that nitrate is an inhibitor of corrosion because they fail to take account of the loss of nitrate by electrochemical reaction. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-108 - MOLTEN SALT CORROSION OF THE CANISTER

1. A statement of the contention itself

SAR Subsection 2.3.6 and similar subsections, which treat the corrosion of the Alloy 22 canister, fail to consider molten salt corrosion.

2. A brief summary of the basis for the contention

In the evaluation of the uniform corrosion of Alloy 22 in SAR Subsection 2.3.6.3.2.2 it is assumed that passive corrosion continues with the same mechanism up to 200°C, but in SAR Subsection 2.3.6.4.4.1 it is assumed that localized corrosion of the Alloy 22 will not occur at temperatures above 120°C, and in SAR Subsection 2.3.6.5.2.1 only tests in liquid salt solutions up to a maximum temperature of 125°C are reported; however, all of these assumptions ignore evidence that liquid phases (concentrated salt solutions or molten salts) that are capable of causing corrosion can be formed up to the maximum operating temperature expected and are liable to change the corrosion mechanism.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

In "Features, Events, and Processes for the Total System Performance Assessment: Analyses," ANL-WIS-MD-000027 REV 00 (3/6/2008), LSN# DEN001584824 at 6-706, it is stated that "four-salt mixture, $NaCl + KNO_3 + NaNO_3 + Ca(NO_3)_2$, with specific proportions can transition directly [from an aqueous solution] to anhydrous melts (i.e., they do not exhibit a maximum boiling temperature)." It is well known in the corrosion community that molten salts may be significantly more corrosive than aqueous solutions, both because the temperature tends to be higher, and because of the potential for fluxing oxides that are protective in aqueous solutions. However, there is no attempt to consider the possibility of molten salt corrosion in the SAR despite this clear evidence that molten salt mixtures can form with species that are expected to be available from the unsaturated zone water. The inclusion of molten salt corrosion may significantly degrade the performance of the waste package and the performance of the waste package is linked to the predicted dose to the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6 and similar subsections, which treat the corrosion of the Alloy 22 canister, because they fail to consider molten salt corrosion. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-109 - MOLTEN SALT CORROSION OF THE DRIP SHIELD

1. <u>A statement of the contention itself</u>

SAR Subsection 2.3.6.8 and similar subsections, which treat the corrosion of the drip shield, fail to consider molten salt corrosion.

2. <u>A brief summary of the basis for the contention</u>

In the evaluation of the uniform and localized corrosion and stress corrosion cracking of Ti7 in SAR Subsection 2.3.6.8 only bulk aqueous solutions are considered, despite evidence that liquid phases (concentrated salt solutions or molten salts) that are capable of causing corrosion can be formed up to the maximum operating temperature expected.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. §

63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In "Features, Events, and Processes for the Total System Performance Assessment: Analyses," ANL-WIS-MD-000027 REV 00 (3/6/2008), LSN# DEN001584824 at 6-706, it is stated "four-salt mixture, $NaCl + KNO_3 + NaNO_3 + Ca(NO_3)_2$, with specific proportions can transition directly to anhydrous melts . . . ." It is well known in the corrosion community that molten salts may be significantly more corrosive than aqueous solutions, both because the temperature tends to be higher, and because of the potential for fluxing of oxides that are protective in aqueous solutions. However, there is no attempt to consider the possibility of molten salt corrosion of the drip shield in the SAR, which if considered may significantly degrade the performance of the drip shield and the performance of the drip shield is linked to the predicted dose to the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.6.8 and similar subsections, which treat the corrosion of the drip shield, because they fail to consider molten salt corrosion. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with § 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform.

Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-110 - ROCK BOLT CORROSION

1. <u>A statement of the contention itself</u>

SAR Subsection 1.3.4.4.1 and similar subsections, which claim that the corrosion performance of the rock bolts will be satisfactory in the 100-year pre-closure period, fail to consider realistic environments or modern understanding of corrosion processes.

2. <u>A brief summary of the basis for the contention</u>

SAR Subsection 1.3.4.4.1 claims that the stainless steel rock bolts and perforated stainless steel sheets are expected to fulfill their functions during the pre-closure period without excessive corrosion, but the supporting document referred to presents a seriously inadequate analysis of the corrosion processes involved and greatly underestimates the potential for failure.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.4 at 1.3.4-8 states "[t]he ground support system is designed to last at least 100 years without planned maintenance even in the severe environmental conditions to be expected in the emplacement drifts," while SAR Subsection 1.3.4.4.1 at 1.3.4-11 claims "[t]he stainless steel rock bolts and perforated stainless steel sheets are expected to fulfill their functions during the pre-closure period without excessive corrosion (BSC 2003c, Sections 7.3

and 7.4)." The analysis on which these statements are based (*see* "Longevity of Emplacement Drift Ground Support Materials for LA" (9/16/2003), LSN# DN2001087393) presents a very incomplete view of the corrosion processes involved. It takes no account of the deposits of concentrated salt solutions that are liable to be formed near the drift end of the rock bolts, and makes almost unbelievably out-dated statements about SCC of stainless steels, claiming that SCC will not occur at temperatures below 100°C. However, SCC of type 316 stainless was reported by Shoji (*see* Shoji, S. and Ohnaka, N. (1989), "Effects of Relative Humidity and Chloride Type on Stainless-Steel Room-Temperature Atmospheric Corrosion Cracking," 38 CORROSION ENGINEERING, 111-119 at 113) at temperatures as low as 25°C in the presence of salt deposits containing $MgCl_2$. Rock bolt failure seems likely, and will potentially allow drift collapse before repository closure, leading to an inability to install the drip shields.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.4.4.1 and similar subsections, which claim that the corrosion performance of the rock bolts will be satisfactory in the 100-year pre-closure period, because they fail to consider realistic environments or modern understanding of corrosion processes. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers, and that degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(k) Waste Dissolution

NEV-SAFETY-111 - HLW WASTE GLASS DISSOLUTION

1. A statement of the contention itself

SAR Subsection 2.3.7.9 and similar and related subsections, which state and/or assume that HLW borosilicate waste glass degradation and radionuclide release rates can be congruently modeled with only orthosilicic acid controlling glass dissolution, are incorrect because in an advective flow regime and under acidic conditions different more rapid modes of dissolution will occur.

2. A brief summary of the basis for the contention

The DOE model is, at best, applicable only to a narrow range of near-neutral pH, a limited temperature range and conditions in which the reacting aqueous phases are ponded with the waste glass. Therefore, it is not applicable to the wide range of pH values and temperatures adopted by DOE. Also, it is not applicable to conditions recognized as applicable by DOE in which water flows through a waste container rather than being ponded within it.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations to support scientific or factual materials

DOE bases its estimates of rates of glass dissolution on a congruent dissolution model that applies only at moderate pH and low temperature. This model also applies only when the aqueous regime around the glass is static or quasi-static, allowing glass dissolution products to build up in the reacting fluids and a protective gel layer to form.

An attempt is made to validate the model (*see* SAR Subsection 2.3.7.9.3.2) under these conditions using data for natural basaltic glass in seawater at pH 7-9 and 3˚C, which are clearly not Yucca Mountain environmental conditions (*see* SAR Subsections 2.3.7.5.3.1, 2.3.7.5.3.2 and 2.3.7.9.3 – inside waste form pH minimum of 5, 25˚C to 100˚C for liquid water, above 100˚C for vapor environments; and with test environments that range from pH 2 to 10.3 (*see* SAR 2.3.7.7.2)). However, in realistic advective conditions in the repository that are accepted as relevant by DOE (*see* SAR Subsection 2.3.7.7.2 which uses dynamic flow-through and drip tests), orthosilicic acid no longer controls the reaction rate, and in the lower pH environments (pH of 6 and below, *see* SAR Figure 2.3.7-28 and SAR Table 2.3.6-1) the protective gel layer will not form (*see* Morgenstein, M., Wickert, C.L., and Barkatt, A. (1999), "Considerations of Hydration-Rind Dating of Glass Artifacts: Alteration Morphologies and Experimental Evidence of Hydrogeochemical Soil-Zone Pore Water Control," JOUR. ARCHAEOLOGICAL SCIENCE, Vol. 26 at 1193-1210).

Further, of the five DOE test solutions simulating unsaturated zone water, SAW has a pH of 2.7, and SSW has a pH range of 5.5 to 7 (*see* SAR Table 2.3.6-1), so clearly DOE targeted simulated test solutions for in-drift C-22 reactions were apparently ignored for waste glass dissolution suggesting that the DOE test solutions for glass are selectively narrow in compositional range. Therefore, glass dissolution rates will be higher than those adopted by DOE, radionuclide release rates will be larger and radiological impacts on the reasonably maximally exposed individual will be increased.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.7.9 and similar and related subsections, which state and/or assume that HLW borosilicate waste glass degradation and radionuclide release rates can be congruently modeled with only orthosilicic acid controlling glass dissolution, because they are incorrect, since in an advective flow regime and acidic conditions different more rapid modes of dissolution will occur. Thus, SAR Subsection 2.3.7.9 and similar subsections do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must evaluate in detail the degradation, deterioration, or alteration processes of engineered barriers if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to

each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-112 - HLW WASTE GLASS DEGRADATION

1. A statement of the contention itself

SAR Subsection 2.3.7.9.3 and similar subsections, which utilize a release rate formula for HLW glass degradation employing a glass surface area exposure factor that ranges between 4 and 17, are based upon insufficient laboratory testing and exclusion of a fundamental hydration reaction, and therefore result in an incorrect measure of radionuclide release.

2. A brief summary of the basis for the contention

10 C.F.R. § 63.114(g) requires DOE to provide a technical basis for models used in the performance assessment including, in particular, laboratory testing. However, DOE utilized an exposure factor that was based upon inadequate and misinterpreted laboratory testing and totally disregarded the non-isovolumetric hydration glass reaction, where quadratic increases in physical stress occur resulting in brittle failure and therefore quadratic increased surface area with time.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(g) requires DOE to provide a technical basis for models used in the performance assessment including, in particular, laboratory testing. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention along with appropriate citations to support scientific or factual materials</u>

SAR Subsection 2.3.7.9.3 at 2.3.7-47 and "Defense HLW Glass Degradation Model, ANL-EBS-MD-000016 REV 002" (10/20/2004), LSN# DN2002139023 at 6-11 and 6-12 determine the rate of radionuclide release from HLW glass when it comes into contact with water as the product of three fundamental terms:

- the surface area of the glass contacted by water;
- the degradation rate of the glass; and
- the mass fraction of the radionuclide in the glass.

This contention speaks only to the first term – the surface area of the glass – and identifies two issues of concern.

In SAR Subsection 2.3.7.9.3, at 2.3.7-49, the exposure factor is defined as a factor that is used because "glass cracks from thermal and mechanical stresses generated as glass cools in the pour canisters." There is absolutely no indication that this function also represents fracturing caused by hydration volume increases. Moreover, the fracture system created during the thermal cooling of the glass is only a portion of the total stress field for a breached canister. For a canister that has not breached (i.e., there is no water in contact with the waste glass), the exposure factor stress envelope might accurately describe the fracture system. However, once water enters the canister and hydration proceeds, the increased volume due to hydration product formation (gel for example along tensile cooling fracture pathways) will create a new tensile fracture net that will respond to glass diagenesis. This new fracture system will be growth dynamic in response to continuing hydration reactions to the extent that the available surface area will increase geometrically with time-and-rates of reaction. Critical with respect to DOE’s calculation of the f-factor, the new fracture net will change the old cooling fracture net to the extent that shear displacements can occur along the old net. The old net fractures were created as tensile displacements. Thus, the fracture apertures of the old fracture net will obviously change. This change in fracture aperture will change the limited access to water in interior cracks. DOE's experimental basis for estimating values of the exposure factor is flawed and its conceptual basis for estimating it is inadequate.

First, DOE’s laboratory-testing program has produced insufficient data upon which to base its findings. Further, DOE has decided not to utilize all of its laboratory results. Specifically, "Defense HLW Glass Degradation Model ANL-EBS-MD-000016REV01F"

(08/04/2003), LSN# DN2001053803, Section 7.2, at 86, speaks to the calculation of the exposed glass surface area in the TSPA-LA as follows:

> Few data are available to verify the surface area accessible to water in a full-sized glass log. Tests with approximately 12-inch long and 24-inch diameter sections cut from a nonradioactive glass log (SRL 165 glass) were conducted as scaled-up [(28-day)] MCC-1 static leach tests (Bickford and Pellarin 1987). The authors estimated a 25-to-35-fold increase in the surface area due to cracking. The results of the scaled-up tests were within 3x the results of typical laboratory tests with 1-cm diameter and 2-mm thick samples on a per area basis. The authors attributed much of the difference to the greater roughness (surface finish) of the larger samples. The factor of 3x is slightly less than the lower end of the range of exposure used in the base model (i.e., 4 - 17).

As reported in DN2002139023 at 22, Sene, M.R., Baily, M., Illerhaus, B., Goebbeis, J., Haase, O., Kulish, A., and Godon, N. (1999), "Characterization of Accessible Surface Area of HLW Glass Monoliths by High Energy Accelerator Tomography and Comparison with Conventional Techniques," EUR 19119 EN (Luxembourg, Luxembourg: Commission of the European Communities), TIC: 254444, ran smaller samples of R7T7 glass logs using large-scale Soxhlet tests. Sene, *et al.* (1999) reports (at Table 13) fracture ratio (measured surface area/geometric surface area) for sample 2 gives a range of 13 to 61, but the other samples range from 4 to 17.

There does not appear to be any mechanistic rationale to support the concept that 4 - 17 is the correct exposure factor range based upon DOE laboratory data presented in support of their calculation as provided in ANL-EBS-MD-000016 REV 01F, DN2001053803 at 86. When DOE scaled up their experiments, it obtained a broader range of values. If DOE were to utilize a single glass log equal in size to the waste form during a long-term experiment, the results might be considerably different from those presented in the SAR.

Second, hydration of borosilicate glass (HLW waste glass) follows the behavior of sideromelane (basaltic glass). This behavior is non-isovolumetric due to the increases in volume during the hydration process. These increases in volume cause stresses that are released by brittle fracture failure of the glass. There is a geometric increase in surface area of the glass log through time during this process. *See, e.g.*, Pulvirenti, A.L., Eddy, S.J., Calabrese, T.M., Adel-Hadadi, M.A., Barkatt, A., and Morgenstein, M. (2006), "Interaction of iron containing silicate glasses with aqueous salt solutions," 47 PHYS. CHEM. GLASSES: EUR. J. GLASS SCI. TECHNOL. A., Vol. 1 at 47-57, and Morgenstein, M. and Shettel, D.L. (1994), "Volcanic Glass as a Natural Analog for Borosilicate Waste Glass," 333 MAT. RES. SOC. SYMP. PROC. 605-615, NEV0002960, LSN# NEV000001849. Thus, time is an important element, as is the rate of the hydration, when considering the evolution of surface area due to fracturing. The increase in surface area, or the DOE exposure factor, is a product of the degradation rate of the glass, which is dependent upon the chemistry of the glass, the chemistry of the reacting aqueous fluids, and the temperature of the environment. As temperature and aqueous fluid chemistry are dynamic over time in the waste emplacement environment, simplistic laboratory experiments of short duration in aqueous compositions such as J-13 or deionized water cannot be expected to address the issue of the range of change in glass surface area during leaching in the Yucca Mountain environs. DOE's exposure factor of 4 – 17 does not address this issue. DOE has used short-term experiments to characterize a long-term process and has adopted the wrong water types for use in those short-term experiments. In fact, it does not even consider hydration volume increases as a cause of fracturing; consequently, DOE's calculated rates of radionuclide release cannot be correct.

The process of hydration stress fracturing in both natural acid and mafic glasses is well documented in the open literature. *See, e.g.*, Apps, J.A. (1987), "Alteration of Natural Glass in Radioactive Waste Repository Host Rocks: A Conceptual Review," LBL-22871, LSN# DN2002225776; Luo, J.S., Abrajano, Jr., T.A., and Ebert, W.L. (1998), "Natural Analogues of Nuclear Waste Glass Corrosion," ANL-98/22 (Argonne National Laboratory), LSN#

DN2002396360; and Pulvirenti, A.L., Eddy, S.J., Calabrese, T.M., Adel-Hadadi, M.A., Barkatt, A., and Morgenstein, M. (2006), "Interaction of iron containing silicate glasses with aqueous salt solutions," 47 PHYS. CHEM. GLASSES: EUR. J. GLASS SCI. TECHNOL. A., Vol. 1 at 47-57. Because DOE failed to develop a comprehensive theoretical basis and associated experimental implementation, they underestimated the increase in available surface area of the glass hence underestimating the rate at which radionuclide releases would increase with time. Increasing this rate would result in an increase of dose to the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.7.9.3 and similar subsections, which utilize a release rate formula for HLW glass degradation employing a glass surface area exposure factor that ranges between 4 and 17, because they are based upon insufficient laboratory testing and exclusion of a fundamental hydration reaction, and therefore results in an incorrect measure of radionuclide release. These subsections do not comply with 10 C.F.R. § 63.114(g), which requires DOE to provide a technical basis for models used in the performance assessment including, in particular, laboratory testing.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many

thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(l) Sorption and Retardation in the Unsaturated Zone

NEV-SAFETY-113 - COMPETITIVE SORPTION IN THE UNSATURATED ZONE

1. A statement of the contention itself

SAR Subsection 2.3.8.3.1, and similar and related sections, assume without validation that "chromatographic effects" will limit the competitiveness of mixtures of radionuclides (and other cations and metals) for sorption sites in the unsaturated zone during transport.

2. A brief summary of the basis for the contention

DOE assumes without proof that the laboratory-determined radionuclide retardation coefficients, K_d, for single radionuclides, used for transport in the unsaturated zone (SAR Subsection 2.3.8), are independent of any conceivable mixture of radionuclides (and metals or other cations) because "chromatographic effects" will limit competition for sorption sites.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the

post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(a) (also part of Subpart E) requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE has performed laboratory experiments for sorption that consist of one of two types of starting waters (J-13 well water and a deep carbonate ground water), a solid (usually crushed tuff), and a single radionuclide. There have been no experiments performed with pairs of radionuclides, or triplets, or any other combination of radionuclides because it has been assumed that the concentrations, for the most part, are too low, or "chromatographic effects" would limit the competition for sorption sites. "Chromatographic effects" refers to the separation of radionuclides that would occur during their transport in aqueous fluids; however, there may never be complete separation of all radionuclides released from a source to a flowing or fingering stream of aqueous fluid in the unsaturated zone. Any separation due to "chromatographic effects" would increase with the distance transported, and would be minimal closest to the source (in the unsaturated zone), and be greatest after miles of transport in the saturated zone (groundwater flow) due to dispersion, advection, and differential sorption. Also lacking by DOE, in SAR Subsection 2.3.8.3.1, are any sorption experiments that include metals from corrosion of the waste packages (Ni, Cr, Mo, W, and Fe) or that include any variations in the normal cations in natural groundwaters (Ca, Mg, Na, and K).

In summary, any "chromatographic effects" would increase with distance from the source and would likely be minimal in the unsaturated zone; also fingering of flow and limited fracture-matrix interaction in the unsaturated zone would likely reduce any residual effects. Thus, the assumption of limited competition for sorption sites by radionuclides (or metals, or other cations) in the unsaturated zone is unproven and lacks validation by DOE. Also, competition between radionuclides and other contaminants for sorption sites will decrease the degree of sorption of individual components of the mixture and hence increase the rapidity of their transport through the unsaturated zone reducing travel times for radionuclides transported to the accessible environment and hence increase doses received by the RMEI.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted.

This contention challenges SAR Subsection 2.3.8.3.1, and similar and related sections, in that it assumes without validation that "chromatographic effects" will limit the competitiveness of mixtures of radionuclides (and other cations and metals) for sorption sites in the unsaturated zone during transport. This does not comply with 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. It also does not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures or with 10 C.F.R. § 63.114(a), which requires data related to geology, hydrology and geochemistry to be used to define parameters and conceptual models used in the performance assessment. Finally, it does not comply with 10 C.F.R. § 63.115, which requires that the LA should address barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-114 - APPLICABILITY OF SORPTION DATA

1. A statement of the contention itself

SAR Subsections 2.3.8.1, 2.3.9, 2.1.2.3, 2.1.4 and similar subsections, which describe sorption characteristics of the upper and lower natural barriers, are not an adequate basis for safety assessment since they evaluate the retardation potential of the host rock data from crushed tuff column experiments that do not represent *in situ* characteristics of sorption.

2. A brief summary of the basis for the contention

The surface area and geometry of crystal faces exposed in crushed column experiments enhance retardation over what would occur in natural fracture and matrix flow conditions; therefore, DOE takes too much retardation credit for cation exchange reactions in its safety assessment calculations. Groundwater composition and ion competition affect zeolite and clay sorption capacity and are not appropriately treated in the DOE experiments.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(b) requires that any performance assessment used to demonstrate compliance with Section 63.113 must account for uncertainties and variables in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE does not take credit for sorption in fractures because there are no mechanisms to ascertain the distribution of sorbing authigenics on fracture walls, and the orientation of these minerals that do occur such as clinoptilolite and heulandite are critical with respect to sorption capacity that varies depending upon which crystal faces are exposed. *See* Burns, R.G., Bowers, T.S., Wood, V.J., Blundy, J.D., and Morgenstein, M. (1990), LSN# NEV000000568. Further, all of the authigenics formed on fracture surfaces do not have sorption capacity – for example, opal is non-sorbing. These non-sorbing diagenetic minerals can, and commonly do, coat sorbing diagenetic minerals, so that some unknown portion of the sorbing mineral population is not available for cation exchange reactions because there is no connectivity between the mineral and the transporting fluids. Cation selectivity is dependent on the authigenic minerals exposed as well as on the cocktail of radionuclides and other ions in transit. These variables are not temporally or spatially predictable. Finally, fluid residence time is unknown in any particular fracture area or rock formation. Therefore, it is almost impossible to obtain a reasonable understanding of the sorption values for fracture rock surfaces in transport pathways in the unsaturated zone (above and below the repository).

With the above understanding in mind, DOE does however make allowance for sorption in the Calico Hills formation because it views matrix transport in this formation as being similar to an unconsolidated porous medium that contains sorbing phyllosilicates. Further, the general concentration of sorbing minerals in the Calico Hills formation is far greater than what might be found in welded tuff fracture networks. If DOE's concept of transport in the non-welded Calico Hills formation were true, then their approach to sorption in this formation would be, in part, valid. However, this is not the case because transport in the Calico Hills formation is channeled and is, therefore, with respect to sorption, similar in principle to fracture transport. Consequently, the exposure capacity of authigenic minerals in the Calico Hills formation is limited to the distribution of exposed (not coated by calcite, opal or other polymorphs of quartz) sorbing authigenics in the channels. This is a confined transport space in comparison with either the calculated or measured unchanneled Calico Hills pore matrix volume or the full extent of fracture surfaces. There is no correlation between the surface area of matrix pore space and that associated with channeled transport in porous media. DOE utilizes the full sorbing mineral inventory of the Calico Hills formation rather than a limited volume of sorbing minerals that actually will see transporting fluids. Non-sorbing authigenics tend to line the channels in porous media because calcite and opal (for example) fills pore space along flow pathways due to evaporation and other hydrogeochemical reactions along these pathways. Calcite and opal pore fillings usually build the channel walls of active transport pathways at Yucca Mountain. Consequently, there is not that much difference between fracture and matrix channel sorbing authigenic mineral distributions. DOE takes significant credit for one (Calico Hills) but no credit for the other (unsaturated zone fracture and faults). These calculations are inconsistent.

To compound its error, DOE has attempted to quantify sorption using crushed tuff that exposes too much surface area and also zeolite crystal face surfaces that have greatly different sorption capacities. DOE has completed extensive non-competitive single ion batch column sorption experiments at Los Alamos to identify the sorption characteristics of each of the tuff formations present at Yucca Mountain. These experiments utilized crushed tuff and represent data that would be applicable to simplified (single ion) sorption reactions in unconsolidated sand. These column experiments do not have the modeling capability to mimic fracture flow conditions in tuffaceous rocks, nor do these experiments mimic transport and retardation in a porous tuff matrix such as found in the Calico Hills formation. Some of the reasons for this observation are as follows:

1) Crushed tuff experiments incorrectly expose all crystal faces to transporting fluids and sorption in different axial directions differs greatly. Natural growth favors the exposure of some faces over others, and many times only one face is exposed. Cation exchange reactions are crystal structure dependent.
2) Specific surface areas for reactions in crushed tuff experiments are so much greater than exposed specific surface areas for either fracture flow or matrix transport in the Yucca Mountain environment.
3) Residence times for the experimental reactions are not necessarily bounding for *in situ* Yucca Mountain transport and flow.

4) Crushed tuff batch experiments do not use multiple competing ions in aqueous solution. State of Nevada competing reaction experiments (*see* Burns, R.G., Bowers, T.S., Wood, V.J., Blundy, J.D., and Morgenstein, M., "Reactivity of Zeolites forming in vitric tuffs in the unsaturated zone at Yucca Mountain, Nevada" (1990), LSN# NEV000000568) found that uptake of long-lived ^{135}Cs into clinoptilolite (the most common zeolite present at Yucca Mountain) may be compromised by competitive effects. The Cs uptake decreases with dilution, in the presence of $NaHCO_3$, and in competition with Ba and Sr. Further, Los Alamos batch column experiments utilized J-13 saturated zone water, but not water compositions appropriate to the unsaturated zone. It is clear that groundwater composition greatly affects zeolite sorption capacity and that the J-13 water composition is not representative of the unsaturated zone of Yucca Mountain.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsections 2.3.8.1, 2.3.9, 2.1.2.3, 2.1.4 and similar subsections, which describe sorption characteristics of the upper and lower natural barriers, base the retardation potential of the host rock upon crushed tuff column experiments that overly estimate sorption capacity and do not represent Yucca Mountain conditions. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must account for uncertainties and variables in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment.

NEV-SAFETY-115 - MATRIX DIFFUSION

1. A statement of the contention itself

SAR Subsection 2.3.8 and similar subsections, dealing with matrix diffusion, utilize percolation fluxes that are based upon mean values rather than on individual storm events, thereby overestimating the diffusion of radionuclides during fracture-matrix interactions, even before consideration is given to additional effects due to the degree of radionuclide dilution, and authigenic mineralization along fracture wall surfaces causing matrix pore and micro-fracture plugging, which together make matrix diffusion insignificant during fracture flow transport.

2. A brief summary of the basis for the contention

DOE takes too much credit for matrix diffusion because, if the matrix is 90 percent or more saturated, liquid diffusion from a fracture (in which flow is an event-dominated, pulsed gravity driven process and not continuous) has to be an extremely slow process in comparison with the downward event-driven flux of fracture flow transport, and therefore, the amount of retardation due to matrix diffusion is insignificant.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(h) requires that any performance assessment used to demonstrate compliance with Section 63.113 must account for uncertainties and variables in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 2.3.8 deals with diffusive properties through laboratory analysis (*see* SAR Subsection 2.3.8.2) and field analysis (*see* SAR Subsection 2.3.8.4.4). The conceptual DOE argument that the key and other radionuclides will be retarded by matrix diffusion (considering tortuosity and free water diffusion) assumes slow enough transport for there to be sufficient time for radionuclides to diffusively migrate into the near-saturated to saturated matrix pores and/or micro-fractures (i.e., fracture-matrix interaction). Slow transport arises in the DOE modeling approach by utilizing the mean annual infiltration rate. However, this is of little relevance in describing individual events, and it is the individual events that provide pulse flow. Consequently, if there are only a few infiltration events during a year, the actual rates of transport can be considerably higher for one event than for the mean, and thus the transport flux through the system for that event will result in a different fracture-matrix interaction. Between events one would also expect that the fracture systems will dry out to a thin-skin along the fracture walls as the plug of water moves into the saturated zone. Radionuclide concentrations within this thin-skin are presumed to be quite minimal so that actual radionuclide diffusion into the matrix between pulsed flows should be rather insignificant. Further, often the thin-skinning results in authigenic mineralization, where opal and calcite dominate the neomineral morphologies. These authigenics also often clog matrix pore space. As time increases with more cyclic transport and dry out events, the production of plugging authigenic minerals (calcite and opal) become more dominant and consequently matrix diffusion, for example, may be less significant during-cool down than during the peak thermal period. In the saturated zone, fractures are continuously filled with groundwater and matrix pores have been in the state of saturation for a long time period. Here authigenic mineralization occurs along most fracture surfaces due to rock-water interactions. Consequently, the authigenic mineral suite present is larger than what is observed in the unsaturated zone. In addition to opal and calcite, there are clays, zeolites and manganese oxyhydroxides present along fracture walls. These minerals provide extensive clogging of the matrix pores in the fracture wall zones thereby greatly reducing matrix diffusion. These authigenics also provide for additional sorption reactions along fracture wall surfaces; however, due to long-term exposure to many different transporting ions these sorption sites are dominantly filled with the most favorable ions (Cs for example), and most of these ions are not derived from the waste form.

In summary, matrix diffusion is limited in the unsaturated zone because downward gravity driven transport of the fracture pulsed-flow is too rapid for effective imbibition into the matrix; and fracture wall pores and micro-fractures eventually become clogged with non-sorbing authigenic minerals. In the saturated zone, authigenic mineralization of the fracture walls is more extensive than in the unsaturated zone due to the long-term of water-rock interactions. Here a large variety of authigenic minerals plug matrix pores and micro-fractures along the fracture walls so matrix-fracture interactions are minimal. Some of these authigenics are strong sorbers, but their sorption sites have already been filled with highly selective natural exchange ions such as Cs and K, so that radionuclides of lower selectivity do not sorb in these competitive situations (for example non-radionuclide ions: Cs, Ca, K, and Na in the super-cage sites in clinoptilolite; common transition metals in the sorption sites of todorokite).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.8 and similar subsections, dealing with matrix diffusion, utilize percolation fluxes that are based upon mean values rather than on individual storm events, thereby underestimating the flux of fracture flow and overestimating the diffusion of radionuclides during fracture-matrix interactions. Further, DOE underplays the importance of diagenetic mineral reactions in plugging the pores and micro-fractures along fracture transport pathways. In consequence, these subsections do not comply with 10 C.F.R. § 63.114(h), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must account for uncertainties and variables in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(m) Geochemistry of the Saturated Zone

NEV-SAFETY-116 - SATURATED ZONE REDOX CONDITIONS

1. A statement of the contention itself

SAR Subsection 2.4 and similar and related subsections, which state or assume that potential variations in redox conditions (reducing or anoxic conditions) in the saturated zone could enhance radionuclide adsorption, are unrealistic and invalid. Therefore, this aspect of the PMA (LSN# DN20023695678) is invalid and cannot be used in support of post-development validation of the TSPA.

2. A brief summary of the basis for the contention

DOE's assumption that radionuclide adsorption would be enhanced by potential reducing (anoxic) conditions in the saturated zone is without foundation as no such reducing zones have been delimited beneath the repository footprint.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository. 10 C.F.R. § 63.102(h)

(part of Subpart E) requires a description of the capabilities of the natural barriers in the setting of the geologic repository, including retardation of radionuclides in the saturated zone, to isolate radioactive waste. 10 C.F.R. § 63.115 (also part of Subpart E) requires an identification of the natural features of the geologic setting that are considered barriers important to waste isolation, a description of their capabilities to isolate waste, and a technical basis for the description. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE has conservatively assumed for TSPA purposes that groundwater flow in the uppermost unconfined volcanic and alluvial aquifers down-gradient from the Yucca Mountain repository occurs under oxidizing (aerobic) conditions, which enhances the solubility and lowers the adsorption coefficient for redox-sensitive radionuclides, such as neptunium (Np) and technetium (Tc). The groundwater occurring in the uppermost unconfined volcanic and alluvial aquifers down-gradient from the repository is oxidizing because it is open to recharge from the surface, exposed to an oxygenated vadose zone several hundred feet thick, and is coarse-grained enough for a thorough mixing under these conditions.

The addition of potential reducing (anoxic) regions in the saturated zone of groundwater flow could indeed enhance radionuclide adsorption and limit solubility of redox-sensitive radionuclides. However, no such reducing regions have been delimited beneath the repository footprint. Although there are reducing regions down-gradient from the repository footprint, it is highly unlikely that groundwater flow bearing redox-sensitive radionuclides would enter those regions. The reducing zones that do exist close to possible groundwater flow paths down-gradient from the repository (the closest one is around well NC-EWDP-5SB) occur in very fine-grained sequences of sediments (primarily clays) that restrict and prohibit normal groundwater flow and are not open to recharging solutions. Without normal groundwater flow in these reducing regions primary organic matter and sulfides have not been oxidized. The very fine-grained nature of these primarily clay-like sediments will prevent and restrict any radionuclide-bearing groundwaters from entering these reducing areas, but may allow diffusion, which is orders of magnitude slower that normal groundwater flow in these paths.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.4.2.3.2.3.2.4 at 2.4-254 discusses potential variations in the redox conditions in the saturated zone as part of the PMA. Nye County's Early Warning Drilling Program ("Nye County Nuclear Waste Repository Project Office, 2001, Independent Scientific Investigations Program Final Report, Fiscal Years 1996-2001: prepared for the U.S. Dept. of Energy" (08/01/2001), LSN# DN2001659890) provides information on the few reducing zones found in wells in the saturated zone south of the repository footprint. For one of these wells, NC-EWDP-1D, the reducing zone is in the carbonate zone which is confined, the deepest zone penetrated, and which does not represent a likely flow path from the repository. None of the three wells with a reducing zone is in a potential groundwater flow path south of the repository footprint. Thus, SAR Subsection 2.4 and similar and related subsections, which state or assume that potential variations in redox conditions (reducing or anoxic conditions) in the saturated zone could enhance radionuclide adsorption, are unrealistic and invalid. Therefore, this aspect of the PMA is invalid and cannot be used in support of post-development validation of the TSPA.

NEV-SAFETY-117 - RADIONUCLIDE SORPTION IN THE SATURATED ZONE

1. A statement of the contention itself

SAR Subsection 2.3.9.3.2.2 and similar subsections, which address radionuclide sorption in the saturated zone, rely on distribution coefficients that are derived from invalid experimental procedures, and as a consequence, the radionuclide transport calculations in the LA cannot be relied upon.

2. A brief summary of the basis for the contention

The experimental data upon which the LA relies for its analysis of radionuclide sorption in the saturated zone is deficient in at least two respects: *first*, the LA relies upon experimental data from sorption experiments in which the initial concentration was above the radionuclide solubility limit in the derivation of radioelement probability density functions, without addressing potential complications arising from precipitation and surface precipitation; *second*, the LA does not adequately quantify or define the dissolved radionuclide concentration upon which its results depend.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.9.3.2.2 and similar subsections state that they rely upon sorption data reported in "Site-Scale Saturated Zone Transport, MDL-NBS-HS-000010 REV 03 ADD 01" (01/02/2008), LSN# DEN001570934, but the Addendum 01 changes only a limited number of pages to the underlying document, and it appears that the LA actually relies upon both Revision 03, "Site-Scale Saturated Zone Transport (Addendum 001, Dated 01/17/08 & ACN-001, Dated 01/11/2008" (01/17/2008), LSN# DEN001573977, and Addendum 01 to Revision 03, LSN# DEN001570934. This clarification is of importance since this contention challenges information presented in Revision 03 rather than Addendum 01. SAR Subsection 2.3.9.3.2.2 at 2.3.9-68 states that the sorption process, as represented by sorption distribution coefficients, contributes to the capability of the saturated zone as a component of the lower natural barrier. This conclusion, however, depends upon experimental data that have at least two significant flaws:

- Experimental data from sorption experiments in which the initial concentration was above the radionuclide solubility limit have been used in determining the radioelement probability density functions (pdfs) without addressing potential complications arising from precipitation and surface precipitation.

- The definition of the dissolved radionuclide concentration, as distinguished from radionuclide associated with solid phases, which is determined by the phase separation method, has not been adequately quantified or defined.

Initial Concentrations above the Solubility Limit

Some of the experimentally determined distribution factors (K_d values) presented in Section A7 of DEN001573977, correspond to calculated **final** concentrations that are above the expected solubility limit for the given radioelement under the experimental conditions. These data were correctly excluded from the data sets used to determine sorption coefficient probability functions. However, other data were inappropriately included for experiments in which the **initial** concentration was above the solubility limit. Such experiments are invalid for determining sorption and an appropriate experimental design would ensure that the initial concentration was below the expected solubility limit, so as to avoid any precipitation occurring over short timescales.

The validity of using of experimental data in which the initial concentration was above the solubility limit depends on an assumption that any precipitated radioelement-containing solids will re-dissolve over the experimental timescale. DOE, however, does not show that this assumption would be correct or even discuss it.

In addition, it is possible that sorption data determined at a final concentration close to, but below, the expected solubility limit may be susceptible to surface precipitation effects, which can occur below the expected solubility limit.

Precipitation and surface-precipitation effects can artificially increase the partitioning of the radionuclide from the solution phase to the solid phase compared to sorption alone. This will potentially lead to an over-estimate of sorption distribution coefficients.

For example, the sorption (as opposed to desorption) experiment data that DOE uses for americium on devitrified tuff in J-13 water presented in Figure A-1 (at A-10) of DEN001573977 relies on experiments where the initial radionuclide concentration was above the solubility limit. The final calculated americium concentrations in all but one (GU3-688) of the sorption experiments are $\sim 10^{-10}$ M/L or above. Given that the K_d values for the experiments with the lowest final americium concentrations are greater than 1000 ml/g, and that the experiments were undertaken with 20 ml of solution to 1g of solid, the initial americium concentrations in the sorption experiments are estimated to be greater than 5×10^{-9} M/L. The americium solubilities at 25°C in J-13 water are reported to be $2.4 \pm 1.9 \times 10^{-9}$ M/L at pH 8.5 and $1.2 \pm 0.3 \times 10^{-9}$ M/L at pH 7. Thus it appears that, with one exception, all of the americium sorption experiments on devitrified tuff were undertaken at initial concentrations above the solubility limit.

The data from sorption experiments with americium on zeolitic tuff, all of the data for thorium and some of the data for strontium, plutonium and neptunium also appear to have had initial radionuclide concentrations that were above the solubility limit. The use of such experimental data is not appropriate to the determination of sorption.

Definition of Dissolved Radionuclide Concentrations

The type and efficacy of the phase separation method is important for defining the actual meaning of the distribution coefficient determined in a sorption experiment. Depending on the nature and fines content of the solid phase, the measured distribution ratio may be dependent on the phase separation method applied. Fine material that would be removed by a fine filter may pass through a coarser filter. Association of radionuclides with the fine particle fraction that were not removed effectively by the phase separation method would lead to lower K_d values being measured. Therefore, it is important that the aqueous concentration of dissolved radionuclides is clearly defined in terms of the phase separation method and conditions used. In addition, the phase separation method used to define the aqueous concentration of dissolved radionuclide in sorption experiments must be the same as that used in solubility experiments if the dissolved fraction is to be defined in a consistent manner.

DOE, however, does not clearly specify the phase separation conditions used in the sorption experiments onto YM tuffs in DEN001573977 or DEN001570934 or in earlier reports (*e.g.*, "Unsaturated Zone and Saturated Zone Transport Properties, ANL-NBS-HS-000019 Rev 00," ICN 2 (12/14/2001), LSN# DN2001606076, all pages). It is also not clear whether the same phase separation method was used consistently across the sorption experiments or whether there was some variation. DOE does not appear to have made any attempt to evaluate the efficacy of the method. Also, it is not clear whether the same phase separation methods were applied in the sorption experiments as in solubility measurements that were used to define solubility limits in the Yucca Mountain groundwaters. Thus, the definition of the dissolved radionuclide concentration has not been adequately quantified or defined. This is a major shortcoming in the work. This may be a reporting issue or it may reflect inadequately defined protocols for the experiments and hence undermine the validity of the data obtained.

According to Section A4, paragraph 3 at A-8 in DEN001573977:

> [T]he solution was separated from the solid phase by either centrifugation or filtration. Centrifugation was preferred for those elements thought to have an affinity for the filter medium.

Unfortunately, DOE provides no further details concerning either filter sizes used or centrifugal conditions applied, and those elements for which centrifugation was preferred are not specified. It does not appear to attempt to quantify the nominal particle size cut-offs in the sorption experiments.

If filtration is used, the pore size of the filter will define a nominal particle size cut-off for the liquid phase. In the same way, the centrifugal field and duration of sedimentation during centrifugation will define a nominal particle size cut-off. In the case of sedimentation, the density of the solid phase also needs to be taken into account.

Because the measured distribution ratio is dependent on the phase separation method applied, it is often the practice to carry out phase separation by more than one method to identify whether this may be an issue. The degree to which the phase separation method has affected the results reported cannot be determined because DOE has made no such comparisons. Additionally, the phase separation method applied should be reported because it is one of the parameters that have to be considered when evaluating sorption (or solubility) data in the determination of a pdf for a sorption distribution coefficient.

The possibility for fines to remain within the solution phase after phase separation has been noted by the DOE authors. It is suggested in Section A4, paragraph 3 at A-8 of DEN001573977 that:

> The separations were not always perfect due to various experimental constraints. In some cases, the concentration in the solid fraction was determined separately from that in the solution. A sorption coefficient was usually calculated from the difference between the initial and final solution concentrations. Corrections were generally made for sorption onto the surface of the test tube during the equilibration (shaking) period.

However, DOE has not adequately addressed the possible implications of fines entrainment for the datasets presented. No attempt appears to have been made to evaluate the effectiveness of the phase separation methods or to identify which results may be affected by the presence of fine material. Without such analysis, the effects of other parameters that will affect measured distribution ratios, such as equilibration time, pH or water composition cannot be determined.

As discussed above, many of the sorption experiments have final calculated radionuclide concentrations that are above measured solubility limits for the radioelements concerned. This may be indicative of the presence of the entrained fine material in the analyzed solutions. The lack of a clear definition of the dissolved phase makes interpretation of these data impossible.

In summary, the sorption data that are relied upon by DOE are not based upon sound experimental protocols and are inadequately reported. Thus, they cannot be used in radionuclide transport calculations for evaluating dose to the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.9.3.2.2 and similar subsections, which rely on distribution coefficients that are derived from invalid experimental procedures. Thus, these subsections do not comply with 10 C.F.R. § 63.114(b), which requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment.

(n) Biosphere Factors

NEV-SAFETY-118 - ESTIMATION OF UNCERTAINTIES IN SOIL-TO-PLANT TRANSFER FACTORS

1. A statement of the contention itself

SAR Subsection 2.3.10.3, and similar subsections, identify the source of soil to plant transfer factors used in the License Application as a number of secondary reviews of relevant literature that are not independent and do not adequately reflect the range of variability in the data reported in the primary literature, such that the performance assessments based on these soil to plant transfers do not fully account for the uncertainties and variabilities in parameter values for 10,000 years after disposal.

2. A brief summary of the basis of the contention

SAR Subsection 2.3.10.3, and similar subsections, identify the source of the soil to plant transfer factors used in the performance assessments as DOE reference document "Environmental Transport Input Parameters for the Biosphere Model" (09/10/2004), LSN# DN2001625960, which in turn relies almost exclusively upon secondary reference sources that typically only give summary data for soil to plant transfer factors and consequently fail to represent the full range of uncertainty and variability recorded in the underlying primary literature.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.10.3 identifies the source of the soil to plant transfer factors used in the performance assessments as DOE reference document "Environmental Transport Input Parameters for the Biosphere Model" (9/10/2004), LSN# DN2001625960. In turn, Section 4.1.1 of DN2001625960 at 4-4 through 4-15 describes the reference sources from which the transfer factors (TFs) were obtained. Therein it is stated that the documents that were used as sources of data for development of the values of TFs are mainly review reports, compendia of biosphere parameter values, and comprehensive dose assessment reports that included the descriptions of biosphere models and the selection of model input parameter values. These documents are all secondary sources and are not independent, as they make use of a common body of knowledge in the primary literature.

Section 6.2.1.1.5 of DN2001625960 at 6-11 through 6-14 describes how the data from these various reference sources were aggregated. First, the geometric mean (GM) was calculated using TF values from all relevant references, then the geometric standard deviation (GSD) was calculated using these same data. As DN2001625960, Section 6.2.1.1.5 at 6-13 comments:

> [T]he sources of information on TFs were summary reviews and reports containing recommendations of generic TF values, or reports describing biosphere models that include selections of input parameters. In either case, the values of TFs are the authors' best estimates for a given radionuclide, pathway, and application. When the GM of such data is calculated, as is done in this analysis, the result represents the estimate of the parameter value based on the best estimates of other authors. The scatter of values, characterized by the GSD, indicates the level of agreement among the authors.

DN2001625960 at 6-13 describes the further manipulation of the GSD values. Specifically, upper and lower limits for the GSD were set based on an analysis of the TFs from the IUR (International Union of Radioecologists) database. The analysis concerned the expected uncertainty in TF values for a range of possible conditions ranging from fully generic to site-specific situations. It was concluded that the most site-specific data (single-site, single-crop) have a GSD of about 1.5. When data are fully generic, the GSD is generally above 3, with a typical value of about 6. Account was also taken of the GSD of 10 that was chosen for all elements in support of biosphere modeling for the Canadian nuclear fuel waste assessment and it was noted that compared with the IUR data this value is an upper limit for GSD values. Because higher values of GSDs are not supported by the existing data, the GSD of 10 was chosen as an upper limit for the TFs for the biosphere model.

From the above description, it is clear that the soil to plant transfer factors used reflect the judgments of various authors of secondary reviews of the literature, who did not have the specific semi-arid agricultural conditions of Amargosa Valley in mind when they undertook their reviews. Indeed, as acknowledged in DN2001625960, Section 6.2.1.1.5 at 6-12, "most of the sources listed in Section 4.1.1 derive information on soil-to-plant TFs from experiments performed on soils typical of temperate climates, and the generic TF values (i.e., values that are recommended if site-specific data are lacking) reflect such conditions." Although the authors made some attempt to correct for this bias, they did so only on the basis of the secondary reviews and not by reference to the primary literature.

Furthermore, many of the secondary reviews gave only best estimates of parameter values, so computing a GSD based on these values does not give any indication of the spread of the underlying data, but only the spread in the authors' evaluations of the central tendency of those data. This problem is compounded by the fact that the various reviews will have relied on many of the same primary data sources and that the later reviewers will have been aware of the recommendations of the earlier reviewers. Therefore, treatment of the results of the reviews as if they were independent data is not legitimate. The subsequent manipulation of the GSD values obtained by reference to generic values given by the IUR or cited in a Canadian assessment study does not have any statistical legitimacy.

In summary, the approach to analyzing the data on soil to plant transfer factors provides results that do not have a statistically well-defined interpretation. Characterization of the results obtained by reference to a GM and GSD implies that an underlying lognormal distribution exists and this is the assumption that has been carried forward into performance assessments. Not only is this not the case, but the analysis presented makes no reference to the uncertainty and variability in the primary data, but only to the variability in some authors' judgments as to the interpretation of those primary data.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. In the case of soil to plant transfer factors, uncertainties and variabilities in parameter values appear to be taken into account through the use of probability distributions. However, these distributions do not have a statistically well defined interpretation and have been determined by an approach that makes no reference to the uncertainty and variability in the primary data, but only to the variability in some authors' judgments as to the interpretation of those primary data.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to

each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-119 - ESTIMATION OF UNCERTAINTIES IN ANIMAL PRODUCT TRANSFER COEFFICIENTS

1. A statement of the contention itself

SAR Subsection 2.3.10.3, and similar subsections, identify the source of animal product transfer coefficients used in the License Application as a number of secondary reviews of relevant literature that are not independent and do not adequately reflect the range of variability in the data reported in the primary literature, such that the performance assessments based on these animal product transfer factors do not fully account for the uncertainties and variabilities in parameter values for 10,000 years after disposal.

2. A brief summary of the basis of the contention

SAR Subsection 2.3.10.3, and similar subsections, identify the source of the animal product transfer coefficients used in the performance assessments as DOE reference document "Environmental Transport Input Parameters for the Biosphere Model" (9/10/2004), LSN# DN2001625960, which in turn relies almost exclusively upon secondary reference sources that typically only give summary data for animal product transfer coefficients and consequently fail to represent the full range of uncertainty and variability recorded in the underlying primary literature.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 2.3.10.3 identifies the source of the animal product transfer coefficients (TCs) used in the performance assessments as DOE reference document "Environmental Transport Input Parameters for the Biosphere Model" (9/10/2004), LSN# DN2001625960. DN2001625960, Section 4.1.6.1, at 4-47 through 4-48, states the sources of data on TCs for animal products consist of reports that summarize measurements of TCs, reports containing recommendations on the environmental transport models and their associated input parameters, and comprehensive dose assessment reports that include selection of input parameter values.

These documents are generally secondary sources and are not independent, as they make use of a common body of knowledge in the primary literature. In particular, some of the sources are compilations of data values for modeling purposes that themselves rely primarily upon secondary literature. *See, e.g.*, Smith, G.M., Watkins, B.M., Little, R.H., Jones, H.M., and Mortimer, A.M. (1996), "Biosphere Modeling and Dose Assessment for Yucca Mountain," LSN# NEV000000097.

DN2001625960, Section 6.3.3 at 6-67 through 6-68 states that the TCs for the biosphere model were developed using a method similar to that used for the development of soil to plant transfer factors for radionuclide transfer to plants. The method was based on review of the pertinent published compendia of generic values or reports containing the recommendations or applications of TC values in other biosphere models. Geometric mean (GM) and geometric standard deviation (GSD) values were calculated. Similar to the recommendations developed for soil to plant transfer factors (*see* DN2001625960, Section 6.2.1.1.5 at 6-11 through 6-14), it was recommended for the cases of large data spread (GSD greater than 10) that the GSD for the TC distributions be capped at 10. If the calculated GSD was less than 2, it was recommended that a GSD equal to 2 be used.

From the above description, it is clear that the TCs used reflect the judgments of various authors of secondary reviews of the literature, who did not generally have the specific semi-arid agricultural conditions of Amargosa Valley in mind when they undertook their reviews. Indeed, DN2001625960, Section 6.3.3 at 6-76 specifically states that the TC values developed are primarily based on generic information and are not specific to the climate or the mode of contamination release (though some exceptions to this position exist, *e.g.* the discussion of plutonium transfers to the meat of cattle grazing the Nellis Bombing and Gunnery Range).

Furthermore, many of the secondary reviews gave only best estimates of parameter values, so computing a GSD based on these values does not give any indication of the spread of the underlying data, but only the spread in the authors' evaluations of the central tendency of those data. This problem is compounded by the fact that the various reviews will have relied on many of the same primary data sources and that the later reviewers will have been aware of the recommendations of the earlier reviewers. Therefore, treatment of the results of the reviews as if they were independent data is not legitimate. This is well illustrated, for example, in DN2001625960, Tables 6-44 and 6-57 at 6-75 and 6-91, where multiple instances of the same point estimate of the TC are recorded from different authors. This would not be expected if independent evaluations of distinct primary data sets had been undertaken. Also, the subsequent modification of the GSD values obtained does not have any statistical legitimacy. Additionally, the analysis assumes that controls on the TCs are not understood, so that values can be selected at random from the distributions generated. For example, in DN2001625960, Table 6-57 at 6-91 all the TC values for chlorine transfers to milk are very similar, as would be expected for an essential metabolic element with relatively constant dietary intakes, but nevertheless the GSD is increased from 1.1 to 2.0, giving an overall range of TC values of 0.0029 to 0.1 d L^{-1}. However, from physiological considerations, Coughtrey, P. J., Jackson, D., and Thorne, M.C. (1983), "Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems, Volume 3" (A.A Balkema, Rotterdam), at 94, demonstrated that the transfer factor for chlorine to milk can be accurately predicted from the amount of stable chloride in the diet of the animal, varying from 0.062 d L^{-1} at 22 g d^{-1} to 0.0038 d L^{-1} at 360 g d^{-1}.

In summary, the approach to analyzing the data on TCs provides results that do not have a statistically well-defined interpretation, do not adequately reflect the underlying primary literature and do not fully take account of factors controlling the values observed. Characterization of the results obtained by reference to a GM and GSD implies that an underlying lognormal distribution exists and this is the assumption that has been carried forward into performance assessments. Not only is this not the case, but the analysis presented makes no reference to the uncertainty and variability in the primary data, but only to the variability in some authors' judgments as to the interpretation of those primary data.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. In the case of animal product transfer coefficients, uncertainties and variabilities in parameter values appear to be taken into account through the use of probability distributions. However, these distributions do not have a statistically well defined interpretation and have been determined by an approach that makes no reference to the uncertainty and variability in the primary data, and the factors influencing the primary data values obtained, but only to the variability in some authors' judgments as to the interpretation of those primary data.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one.

These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-120 - RMEI DIET

1. A statement of the contention itself

SAR Subsection 2.3.10.2.5 and similar subsections identify the animal products included in the biosphere assessment model as meat, poultry, eggs and milk, but fail to consider other animal products such as liver that are likely to be consumed by people who reside in the Town of Amargosa Valley and that are very effective in accumulating radionuclides notably actinides.

2. A brief summary of the basis of the contention

DOE has failed to adequately estimate radiological impacts on the RMEI from consumption of animal products contaminated with radionuclides, by unreasonably restricting the range of animal products considered at an early stage in the overall assessment process.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. Compliance with this

paragraph must be demonstrated through a performance assessment that meets, *inter alia*, the requirements specified at 10 C.F.R. § 63.312. 10 C.F.R. § 63.312(b) specifies that the Reasonably Maximally Exposed Individual (RMEI) has a diet and living style representative of the people who now reside in the Town of Amargosa Valley, Nevada and requires that DOE must use projections based upon surveys of the people living in the Town of Amargosa Valley, Nevada, to determine their current diets and living styles and use the mean values of these factors in the assessments conducted for 10 C.F.R. §§ 63.311 and 63.321. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.10.2.5 at 2.3.10-20 states that "the animal uptake submodel calculated the concentration of radionuclides in animal products for human consumption" and that "[f]our types of animal products (meat, poultry, eggs and milk) . . . were included in this submodel." In this context, meat and milk refer specifically to cattle products (*see* SAR Subsection 2.3.10.3 that identifies the source of the animal product transfer coefficients (TCs) used in the performance assessments as "Environmental Transport Input Parameters for the Biosphere Model" (09/10/2004), LSN# DN2001625960, which in turn shows that the transfer factors used are specific to cattle).

It is further stated in SAR Subsection 2.3.10.2.5 at 2.3.10-20 that "the animal products were selected based on a survey of the diets of the residents of Amargosa Valley (DOE 1997)." The reference cited is "The 1997 'Biosphere' Food Consumption Survey Summary Findings and Technical Documentation" (11/01/1997), LSN# DEN000684324. However, in SAR Subsection 2.3.10.2.2 both DEN000684324 and "ANL-MGR-MD-000005 Revision 04, Characteristics of the Receptor for the Biosphere Model" (04/05/2005), LSN# DN2001870660, Section 6.4 are cited, with the latter being specified as the document in which average consumption rates of locally produced foods are calculated. DN2001870660, Section 6.4.1 at 6-40 states that:

> Estimates of the amount of groundwater and locally produced foods consumed by residents of Amargosa Valley that were surveyed in 1997 are displayed in Figures 6-3 through 6-12. The food groups and methods used to calculate consumption rates are described in Section 6.4.2. The histograms were produced using the information in DTN MO0010SPANYE00.001 [DIRS 154976].

The information used to produce the histograms appears in a complex electronic document, including spreadsheets. "Cleaned Nye County Food Consumption Frequency Survey, DTN: MO0010SPANYE00.001, TDIF 31127" (Special Instruction Sheet for digital information) (10/17/2000), LSN# DEN000429108; "Information Copy & Nye County Food Consumption Frequency Survey Data & Notes on Nye County Food Consumption Frequency Survey Data as of October 6, 2000; SAIC1Qual-2" (10/06/2000), LSN# DN2000124696, all pages; "Technical Data Information Form (TDIF) 311327 for Cleaned Nye County Food Consumption Frequency Survey, DTN: MO0010SPANYE00.001 (This is a Correction to MOL.20001018.0003)" (12/12/2002), LSN# DEN000422740, all pages.

DN2001870660, Section 6.4.2 at 6-48 defines six relevant animal product food groups – beef, pork, wild game, poultry, milk and eggs (aggregated to meat, poultry, milk and eggs).

> For every food group, a series of four questions was asked. The first question asked if the respondent ate any locally produced food in a food group during the past year. Those who answered "yes" proceeded to the second, third and fourth questions. Those who answered "no" skipped to the next series of questions.

Id. at 6-44. From this approach it seems that questions were asked only about these food groups and no attempt was made to determine whether other animal food products were consumed. Examination of the five files provided by DOE to the State of Nevada, which include DEN000429108, DN2000124696, and DEN000422740 as well as the manifest output desktop file MO0010SPANYE00.001.md5 and SAIC1Qual-2.zip, failed to shed any further light on this matter. However, examination of the questionnaire material for the 1997 survey, *see* "The 1997 'Biosphere' Food Consumption Survey Summary Findings and Technical Documentation; Food Consumption Survey 1 of 3" (11/01/1997), LSN# DN2001032585 at 10, revealed that the animal product food groups comprised meat (beef and pork), milk, poultry and eggs. Therefore, it seems that consumption of other animal food products, such as offal, were neglected from the outset of the work.

Elsewhere, it is recognized that offal is a significant component of the diet. In the United Kingdom, consumption rates of meat and meat products typically used in radiological impact assessments are shown in Byrom, J., Robinson, C., Simmonds, J.R., Walters, B., and Taylor, R.R. (1995), "Food Consumption Rates for Use in Generalised Radiological Dose Assessments," J. RADIOL. PROT., Vol. 15 at 335-341). Reproducing that information below, note that offal consumption can be comparable with meat consumption in high-rate consumers.

Foodstuff	**Consumption Rate (kg y^{-1})**					
	Adult		**Child**		**Infant**	
	97.5th Percentile	**Mean**	**97.5th Percentile**	**Mean**	**97.5th Percentile**	**Mean**
Pig Meat	40	15	25	8	5.5	1
Cattle Meat	45	15	30	10	10	3
Sheep Meat	25	3	10	1.5	3	0.6
Offal	20	2	10	1	5.5	0.4
Poultry	30	7.5	15	3.5	5.5	1
Game	15	0	7.5	0	-	-
Eggs	25	8	20	6.5	15	4.5
Total	**180**	**48.5**	**107.5**	**29.5**	**39**	**10.1**

The omission of offal consumption from DOE's questionnaire is of potential significance in the evaluation of the biosphere dose conversion factors used in the TSPA-LA because some of the radionuclides of particular relevance concentrate in offal relative to meat. Thus, for example, in the case of ^{237}Np, typically about 15% of that entering the systemic circulation is deposited in the liver and about 2% in muscle. *See* ICRP Publication 48 (1986), "The Metabolism of Plutonium and Related Elements," Annals of the ICRP, 16(2/3) at 78 (liver value); and Coughtrey, P.J., Jackson, D., Jones, C.H., Kane, P., and Thorne, M.C. (1984), "Radionuclide Distribution and Transport in Terrestrial and Aquatic Ecosystems," Vol. 4 at 516 (muscle value). As muscle has a mass that is about 16 times larger than that the liver (*see, e.g.*, ICRP Publication 23 (1975), "Report of the Task Group on Reference Man," Pergamon Press, Oxford, at 282 and 284) and long-term retention of neptunium occurs in both of these tissues (ICRP Publication 48, *op. cit.*, at 79), ^{237}Np concentrations in animal liver would be expected to be about a factor of 120 larger than those in meat.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.10.2.5 (and related subsections) identifies the animal products included in the biosphere assessment model as meat, poultry, eggs and milk, but fails to consider other animal products such as liver that are likely to be consumed by people who reside in the Town of Amargosa Valley. This failure appears to have arisen from deficiencies in the conduct and/or interpretation of the original survey data. This deficiency is of significance because offal can be of comparable importance to meat in the diet for some individuals and because some radionuclides, such as ^{237}Np, are much more highly concentrated in offal than in meat. Thus, DOE has failed to conform to 10 C.F.R. § 63.312(b) in defining a Reasonably Maximally Exposed Individual (RMEI) who has a diet and living style representative of the people who now reside in the Town of Amargosa Valley, Nevada, and therefore DOE has also failed to carry out performance assessments that meet the performance objectives of 10 C.F.R. § 63.113.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(o) Rock Structure and Geomechanics

NEV-SAFETY-121 - HOST ROCK GEOMECHANICAL PROPERTIES

1. A statement of the contention itself

SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system for the emplacement drifts, reach conclusions about the geomechanical properties of the predominant host rock units used for design based on very limited numbers of physical tests that are insufficient to demonstrate that the rocks hosting the emplacement drifts will contribute to post-closure performance by functioning as a geological barrier.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that the rock properties have been sufficiently characterized to provide reasonable assurance that the geological barrier will function to promote isolation of the waste packages. The limited number of tests used to develop the design geotechnical properties in the predominant host rock units means that the TSPA-LA does not demonstrate that the natural barrier will perform as assumed.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. 10 C.F.R. § 63.114(a) requires that any performance assessment used to demonstrate compliance with § 63.113 must include data related to the geology, hydrology, and geochemistry (including disruptive processes and events) of the Yucca Mountain site, and the surrounding region to the extent necessary, and information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. Furthermore, the failure to adequately determine the geomechanical properties of the rock means that DOE does not comply with 10 C.F.R. § 63.115(b), which requires information on the capacity of barriers, including natural barriers, to isolate waste, since adequate information on the unsaturated zone rock has not been provided. This contention alleges noncompliance with these regulatory provisions, because the information on the geomechanical properties of the walls of the emplacement drifts is not adequate for assessment purposes, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 1.3.4.4 states that 80% of the emplacement drifts will be located in the lower lithophysal subunit (Tptpll) of the Topopah Springs tuff, 5% will be located in the upper lithophysal unit (Tptpul), 10% will be located in the middle nonlithopghysal unit (Tptpmn) and the remaining 5% will be located in the lower nonlithophysal unit (Tptpln). Design property data for the lithophysal units and nonlithophysal units are presented in SAR Table 1.3.3-2 at 1.3.3-53 and SAR Table 1.3.3-3 at 1.3.3-54, respectively.

In the case of the nonlithophysal rock units, these design rock strengths are rock mass properties that were estimated using the intact rock property testing data together with the Rock Mass Rating, Q and GSI rock classification systems and the Hoek-Brown rock strength criterion. *See* Subsurface Geotechnical Parameters Report (01/01/2007), LSN# DN2002371133 at 6-175 to 6-180. These procedures are quite commonly used in the rock engineering community; however, as stated above, the nonlithophysal units represent the host rocks in only 15% of the emplacement drifts. The testing performed in these rock units, therefore, does not represent sufficient characterization of the repository rock mass.

Rock mass properties for the lithophysal units were developed using an alternate procedure based on correlations between strength and porosity and utilizing samples with diameters of approximately ten inches are not commonly used. *See* DN2002371133 Table 6-62 at 6-192 to 6-197. Ten-inch diameter samples are not commonly used for strength testing in rock because of the large load capacity generally required in order to reach yield or failure. Where used, they have often been found to be of sufficient size to represent the rock mass; however, rock mechanics literature has demonstrated that the specimen diameter must exceed eight to ten times the size of features such as grains or flaws in order that the results of testing represent the behavior of the rock fabric rather than the effect of movement along individual grain boundaries or flaws. Taking this rule and the average lithophysae diameter of 10 cm (4 inches), a sample should be at least 80 cm (32 inches) in diameter. Nevertheless, the main limitation for the testing on the lithophysal units is the lack of samples tested and reported. Based on DN2002371133, Table 6-62, at 6-192 to 6-197, only 13 samples of the lower lithophysal unit and 26 samples of the upper lithophysal unit having a diameter of 245 cm or larger were tested for uniaxial compressive strength under ambient temperature conditions and an additional two samples of the lower lithophysal unit and three samples of the upper lithophysal unit were tested for uniaxial compressive strength under elevated temperature (200 °C) conditions. Only two samples of the lower lithophysal unit with diameters of 50 cm (2 inch) and three samples of the upper lithophysal unit with diameters of 61 cm (2.4 inch) were tested under triaxial conditions at ambient temperature conditions with one sample each at different confinement levels. No samples of either lithophysal unit were tested in triaxial compression at elevated temperature conditions. Because it is the rock behavior at elevated temperature that will be critical to ensure that the geologic barrier functions as planned, this lack of testing is unacceptable. Consequently, the characterization of the strength properties of the rock mass presented in the TSPA-LA cannot be considered as adequate to demonstrate that the geologic barrier will function as assumed.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system for the emplacement drifts, because they fail to indicate that the geomechanical properties of the predominant host rock units used for design, which are fundamental to the presumption that the rocks hosting the emplacement drifts will function as a geological barrier, are based on very limited numbers of physical tests. This does not comply with 10 C.F.R. § 63.114(a), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must include data related to the geology, hydrology, and geochemistry (including disruptive processes and events) of the Yucca Mountain site, and the surrounding region to the extent necessary, and information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. Also, by failing to characterize the rock mass properties sufficiently for assessment purposes, SAR Subsection 1.3.4.7 and similar subsections fail to comply with 10 C.F.R. § 63.115(b), which requires information to be provided on the capacity of barriers, including natural barriers, to isolate waste.

NEV-SAFETY-122 - SCREENING OF DRIFT DEGRADATION FEPs

1. A statement of the contention itself

SAR Subsection 2.3.4.1 improperly excludes features, events and processes relating to seismic-induced rockfall damage, non-seismic rockfall and drift collapse that could occur within the first 10,000 years from consideration in the TSPA on the basis of low consequence or low probability.

2. A brief summary of the basis of the contention

SAR Subsection 2.3.4.1 excludes features, events and processes relating to seismic-induced rockfall damage, non-seismic rockfall and drift collapse from consideration in the TSPA on the basis of low consequence or low probability, whereas modeling undertaken by the Center for Nuclear Waste Regulatory Analyses (CNWRA) considers that rubble loading may be sufficient to collapse drip shields, allow seepage to pass through them and contact waste packages allowing localized corrosion to occur.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.113 (part of Subpart E) requires that compliance with that paragraph must be demonstrated through a performance assessment that meets the requirements specified at 10 C.F.R. §§ 63.114 , 63.303, 63.305, 63.312 and 63.342 (the latter four are part of Subpart L). 10 C.F.R. § 63.114(c) requires that any performance assessment used to demonstrate compliance with Section 63.113 for 10,000 years after disposal must consider alternative conceptual models of features and processes, for 10,000 years after disposal, that are consistent with available data and scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository. 10 C.F.R. § 63.342 sets the limit on performance assessments by excluding features, events and processes from consideration that are estimated to have less than one chance in 10,000 of occurring within 10,000 years of disposal, and provides that performance assessments need not evaluate the impacts resulting from any features, events and processes with a higher chance of occurrence if the results of the performance assessments would not be changed significantly in the initial 10,000-year period after disposal. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In SAR Subsection 2.3.4.1, seismic-induced drift rockfall damage to EBS system components is screened from consideration on several grounds. For nonlithophysal units, damage can occur to the drip shields, but advection through cracks in the drip shield and failure of drip shield plates is excluded because of low consequences for the TSPA. Rupture of axial stiffeners is assessed to occur only for an impact of a 28.3 metric ton (MT) rock block and is excluded on the grounds of low probability. Also, damage to waste packages and waste package internals is excluded on the grounds that the drip shields do not separate and because they remain intact mechanically deflecting rockfall away from the waste packages. Seismic-induced rockfall in the lithophysal units is not excluded from the TSPA.

Also in SAR Subsection 2.3.4.1, non-seismic rockfall in both lithophysal and nonlithophysal units, resulting from processes such as drift degradation induced by *in situ* gravitational and excavation-induced stresses and thermally induced stresses, is excluded on the grounds that potential rock block sizes generated by these processes are not sufficient to tear or rupture the drip shield plates, and that potential advective flux through stress corrosion cracks resulting from denting of the drip shield plates by rockfall is of low consequence.

Finally, in SAR Subsection 2.3.4.1, partial and complete drift collapse, as opposed to discrete rockfall is considered, as a result of thermal effects, stresses related to excavation and other non-seismic processes. DOE assesses that drift collapse resulting from excavation and thermal stresses is expected to be relatively minor during the time of the thermal phase and that time-dependent strength degradation of the rock mass over the first 20,000 years after emplacement is expected to result in only partial drift collapse in either lithophysal or nonlithophysal rock masses. From these considerations, the impact of drift collapse on the performance of the drip shield, waste package, emplacement pallet and invert was excluded on the basis of low consequence.

In contrast, the CNWRA describes how drift degradation and the resulting rubble accumulation in an emplacement drift are modeled in TPA Version 5.1 for both lithophysal and nonlithophysal units. *See* "Risk Insights Derived from Analyses of Model Updates in the Total-System Performance Assessment Version 5.1 Code" (7/31/2008), LSN# NRC000029711, Section 4, at 4-1 through 4-3. The drift degradation is taken to occur at a steady rate from thermal loading beginning at the time of closure (*id*. at 4-1). In addition, episodic accumulation of rubble from seismic activity is taken to occur using a linear relationship between ground motion magnitude and rubble accumulation. The rubble load on the drip shields is computed. If it is found to be sufficient to collapse the drip shields, it is assumed that some fraction of the seepage may pass through the drip shields and contact the waste packages. If water contact with the waste packages occurs early in the thermal period, localized corrosion may occur. Also, the rubble load on the collapsed drip shields is assumed to be transferred to waste packages and may be concentrated. If the resulting stress is amplified by seismic acceleration, mechanical damage to the waste package may occur.

Results from the CNWRA analysis shows that the radiological impact of the scenario with thermal degradation, but no seismic degradation, is very much larger than the radiological impact of the scenario without either thermal or seismic degradation. *See* NRC000029711, Figure 4.1 at 4-2. When seismic degradation is also included, the radiological impact is increased further, but the differences between the results obtained with and without thermal drift degradation are reduced. The assessed radiological impacts approach their peak values on a timescale of around 10,000 years, i.e. they are substantially expressed within 10,000 years.

Evaluation of the effects of rockfall and drift degradation on drip shields and waste packages depend on detailed stress and mechanical stability analyses and on interpretation of the effects of mechanical damage on corrosion resistance and water penetration potential. The State of Nevada has not evaluated the extent to which analyses of these effects have been undertaken by DOE and CNWRA, and has not investigated differences between those analyses. Nevertheless, it is clear that DOE and CNWRA have developed very different conceptual models for the consequences of rockfall and drift degradation. These different conceptual models either need to be reconciled, or one needs to be eliminated on the basis of available data and scientific understanding, or both need to be propagated through the DOE performance assessments.

In light of the CNWRA report, DOE's screening of features, events and processes relating to seismic-induced rockfall damage, non-seismic rockfall and drift collapse from consideration in the TSPA on the basis of low consequence or low probability has not been adequately justified, in conflict with 10 C.F.R. § 63.342. Furthermore, the CNWRA position represents, at the very least, an alternative conceptual model that is considered by them to be consistent with available data and scientific understanding and that, therefore, should be evaluated in the performance assessment to comply with 10 C.F.R. § 63.114(c).

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

In SAR Subsection 2.3.4.1, DOE screens various features, events and processes relating to rockfall and drift degradation, however, the screening adopted is not consistent with the position taken on these features, events and processes by the CNWRA in a report that post-dates submission of the License Application. DOE does not recognize in the License Application that any legitimate alternative models of these features, events and processes could be adopted. There is a need to show either that the CNWRA model is inconsistent with available data and scientific understanding, or to update the screening assessment to take account of the legitimacy of this model in conformance with 10 C.F.R. § 63.342 and to propagate it though the performance assessments in accord with 10 C.F.R. § 63.114(c).

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(p) Durability of Components of the Engineered Barrier System

NEV-SAFETY-123 - DURABILITY OF GROUND SUPPORT

1. A statement of the contention itself

SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system in the emplacement drifts, fail to consider that the assumed 100-year life for the Super Swellex™ friction-type rock bolts and the Bernold sheets is speculative because this particular ground support system has been in use for less than 40 years.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that the final rock reinforcement system that consists of three-meter long Super Swellex™ friction-type rock bolts and Bernold sheets will function for at least 100 years. This assumption ignores the uncertainties arising from the fact that Bernold sheets were introduced in the 1960s and friction-type rock bolts were developed in the late 1970s.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect

compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. Also, 10 C.F.R. § 63.114(f) requires provision of a technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.4 at 1.3.4-8 discusses the permanent ground support system, which consists of three meters long, Super Swellex™ friction-type rock bolts together with Bernold sheets. Both the rock bolts and Bernold sheets are specified in SAR Subsection 1.3.4.4.1.5 at 1.3.4-15 through 1.3.4-16 as being constructed of Type 316 stainless steel in order to be corrosion resistant and are specified as having a 100-year expected life. Further SAR Subsection 1.3.4.4.2 at 1.3.4-15 states that "(t)he ground support for the emplacement drifts is designed to function without planned maintenance for the preclosure period even in the severe environmental conditions to be found in the emplacement drifts."

However, there is no proof that rock bolts will last for 100 years because there are no rock bolts of any type of construction that have been in use as long as 100 years. Rock bolts with mechanical anchors were developed at St. Joseph Lead Co. in Missouri in the late 1920s (*see* Casteel, L.W. (1964), "The First Century of Research by St. Joseph Lead Co.," MINING ENGINEERING, 111-111D), whereas the friction-type bolt, of which the Split Set™ was the first, was introduced in 1978 by Dr. Jim Scott. Bernold sheets were developed in the late 1960s by Bernold AG of Walenstadt, Switzerland (*see* Tough, S.G. and Noskiewicz, T.M. (1974), "Pre-Formed Linings in Tunnelling Practice," PROC. RETC, Vol. 1 at 643-668, SME of AIME, San Francisco,). Further, rock bolts are typically manufactured of carbon steel rather than stainless steel so that data on the corrosibility of stainless steel bolts are lacking in any case. Given this lack of data, it is unfounded optimism to predict that the support system will last for 100 years.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system in the emplacement drifts, because they fail to consider that the presumed 100-year life for the Super Swellex™ friction-type rock bolts and the Bernold sheets is unproven as a consequence of this ground support system having been in use for less than 40 years. Because this has not been considered, the assumptions made relating to isolation of the wastes within the waste package are unfounded and the LA does not comply with 10 C.F.R. § 63.114(a), which requires the inclusion of information on the design of the engineered barrier system for use in a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. Also, it does not comply with 10 C.F.R. § 63.114(f), which requires provision of a technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers.

(q) Effects of Fabrication and Welding of Titanium Drip Shields

NEV-SAFETY-124 - WELDING OF ALPHA BETA TITANIUM ALLOY TO UNALLOYED TITANIUM

1. A statement of the contention itself

SAR Subsection 1.3.4, Tables 1.3.4.3 and 1.3.4.4 and other similar and related subsections, which indicated that an all alpha titanium alloy (Grade 7) has been selected for the water diversion surface (WDS) of the drip shields and an alpha-beta titanium alloy (Grade 29) has been selected for structural components, fails to properly demonstrate, test, and account for the phenomena of delayed cracking due to hydrogen migration and precipitation of embrittling titanium hydrides to low solubility alpha material from higher solubility beta phase material, particularly at welds, and therefore DOE has failed to consider associated drip shield failures.

2. A brief summary of the basis for the contention

DOE's apparent failure to adequately consider hydrogen induced delayed cracking, a failure mechanism that has been observed in similar combinations of welded titanium alloys, and DOE's failure to demonstrate and test welds with its proposed combination of different titanium materials leaves open an un-quantified risk of significant structural failure due to delayed weld cracking resulting from hydride precipitation arising from differences in hydrogen solubility between Grade 7 (alpha) titanium and Grade 29 (alpha-beta) titanium.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4, Tables 1.3.4-3 and 1.3.4-4, and other similar subsections, indicated that DOE has selected an all alpha titanium alloy (Grade 7) for the water diversion surface (WDS) of the drip shields, and an alpha-beta alloy (Grade 29) for structural components. The combination of all alpha titanium alloy and an alpha-beta titanium alloy for structural components has been shown in industrial experience to be prone to delayed cracking due to hydrogen migration to, and precipitation of embrittling titanium hydrides in, low solubility alpha material from higher solubility beta phase material. Delayed cracking of titanium, associated with welds between alpha-beta and all alpha alloys, has also been observed in a number of instances. However, DOE has failed to actually demonstrate to what extent this specific combination of materials may be susceptible to delayed cracking due to hydrogen mitigation and precipitation of embrittling titanium hydrides.

Hydrogen will be present in the materials in the drip shield from original titanium material production, and will likely be present in the Grade 29 material at a higher concentration than in Grade 7 material. There is a potential to introduce hydrogen during fabrication due to moisture on surfaces or in shielding gases, due to heating methods that may be required for forming, particularly of Grade 29, and during furnace stress relief of the drip shield assembly. Hydrogen can also be generated by corrosion including general and localized corrosion, and galvanic corrosion. Hydrogen has relatively high solubility in the beta phase of the Grade 29 material compared with the alpha phase in the Grade 7 material. As a result, the American Welding Society in its recent publication on structural welding (*see* AWS D1.9/D1.9M "Structural Welding Code – Titanium"(07/2007)) suggests in C-2.6 that special precautions be applied to joints between alpha and alpha–beta alloys due to risks of hydrogen concentration near weld boundaries.

DOE has failed to produce and test welds made by the required welding processes with materials (Grade 7 to Grade 29 using ERTi-28 filler metal) under conditions where hydrogen can be generated. Therefore, DOE has failed to demonstrate that the weld metal and surrounding material are not subject to hydrogen induced delayed cracking, or to demonstrate the specific precautions that are necessary to prevent hydrogen problems due to welding. DOE has also failed to quantify the effects of relative humidity, metal temperature, preheat, shielding gas quality, welding process, base metal cleanliness, and filler metal cleanliness, on hydrogen pick-up during welding. Finally, DOE has failed to adequately consider the risks of hydrogen increase during gas or fuel-fired furnace stress relief. All these effects could result in premature failures of the drip shields and EBS.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's selection of Grade 7 and Grade 29 titanium materials in combination for a welded drip shield structure, as described in SAR Subsection 1.3.4 and similar subsections, on the basis that known hydrogen effects like delayed cracking have not been adequately tested (by producing actual welds of the materials with the proposed filler metals and testing them), were not adequately considered in the TSPA model development, and were not addressed in the FEP statements, which could impact the dose to the RMEI. Thus, these subsections do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-125 - EFFECTIVENESS OF STRESS RELIEF TO ELIMINATE SCC OR HYDROGEN EFFECTS

1. A statement of the contention itself

SAR Subsection 2.3.6.8.3, which states that the drip shield will be fully stress-relief-annealed before emplacement reducing residual stresses by about 50% or to the point that SCC can be dismissed as an issue, fails to provide adequate information to make this demonstration and DOE did not report tests of actual material combinations proposed for the drip shield; therefore, it must be presumed that unquantified residual stresses could lead to hydride formation in areas of high stress and increased susceptibility to failure under external loads.

2. A brief summary of the basis for the contention

The LA fails to provide supporting data to show how effective the proposed stress relief will actually be on the specific combination of Grade 29 and Grade 7 titanium materials welded with ERTi-28 filler metal, or that stress relief will not introduce other problems such as distortion, unacceptable heavy surface oxide concentrations, or hydrogen pick-up during stress relief.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and

safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The residual stress reduction that will result from thermally treating a Grade 7 to Grade 29 bimetallic titanium weld will not be the same as stress relieving either material independently. As the material cools from 1100ºF, the Grade 29 titanium will pick up substantial strength before the Grade 7 titanium. As the material cools further, the Grade 7 material adjacent to the Grade 29 material will be placed in residual tension, balanced by a compressive residual stress in the Grade 29 material.

Neither the assumption that reducing residual stresses by 50% or that the proposed stress relief will eliminate the risk of stress corrosion cracking (SCC) of the Grade 29 titanium has been demonstrated in the LA. Therefore, the level of these residual stresses and their effect on hydrogen accumulation that could lead to hydride formation and cracking have not been demonstrated in the LA.

In addition, procedures described in the SAR for stress relief are incomplete or incorrect. In the "Design Calculation or Analysis Cover Sheet for Drip Shield and Waste Package Emplacement Pallet Design Report 000-00C-SSE0-00100-000-00B" (08/09/2007), LSN# DN2002459185 at 24 and 25, SAR Requirement 6.2.6.12 is referenced as stating:

> After fabrication the drip shield assembly and lifting feature assemblies shall be stress-relieved; after completion of all required work except for the final machining. The drip shield assembly and lifting feature assemblies shall be furnace heated for stress relief at 1100° Fahrenheit +/- 50° Fahrenheit for a minimum of 2 hours. To prevent pickup of hydrogen, a slightly oxidizing atmosphere shall be used; air-cooling is allowed. (Derived from Reference 2.2.28, Table 1, Item 07-13.)
>
> Satisfaction of Requirement 6.2.6.12: The *Yucca Mountain Project Engineering Specification for Prototype Drip Shield* Yucca Mountain Project Engineering Specification (Reference 2.2.27) sections 2, 3, 4, 5, 6, 7, 8, and 9 impose the specific, applicable sections from codes and standards for the Drip Shield Design, Materials, Fabrication, and Examination and Testing. Air-cooling is expected to provide the "slightly oxidizing atmosphere" mentioned in this requirement.

The referenced discussion is related to a fuel-fired furnace and relates to reduction of the risk of hydrogen pick-up during the heating portion of the stress-relieving process. However, the "slightly oxidizing" environment refers to the furnace atmosphere and not the subsequent air-cooling environment. The suggestion that cooling in air meets the requirement of an oxidizing atmosphere demonstrates a lack of understanding on the part of DOE of how stress relief might be accomplished for the drip shields. The LA's suggested use of a fuel-fired furnace and cooling in air from 1100ºF are certainly sub-optimum. A far safer way to do this stress relief would be to use an electric furnace with an air atmosphere, or better, with an argon atmosphere.

SAR Table 1.9-9, FEP 07-13 suggests that air-cooling from the 1100ºF stress relieving temperature is allowed. However, such a practice increases the risk of thermal distortion due to uneven cooling. Air cooling from the 1100ºF furnace temperature will, in itself, result in non-uniform cooling, non-uniform levels of residual stress, and likely distortion of the non-symmetrical structure.

Normally, one would expect controlled rates of heating and cooling to be part of a stress relieving procedure. The suggested air cooling from full furnace temperature is not normal for a stress relieving cycle. Slow heating in the furnace, and slow cooling in the furnace to a temperature in the range of 400-600ºF would be far safer (from a distortion point of view) than charging into an 1100ºF furnace or air cooling from 1100ºF.

Thermal stress relieving in air (a slightly oxidizing gas furnace or an electric furnace environment) will result in build up of surface oxide of the order of at least 2000-3500 angstroms thickness, compared with around 40 angstroms normal air formed oxide thickness tested in the corrosion work. While this oxide may improve corrosion performance under certain circumstances, it has not been studied in any of the DOE corrosion test work and it could readily produce unexpected results in these specific services. The main issue here is that DOE did not test the material in the condition that they will presumably use it. In typical industrial exposures and durations, one might be comfortable that this would not do any harm. However, for some environments or extended exposures, one cannot really know what performance to expect without testing, and certainly there is nothing that should give confidence that test results on a normal air oxidized surface can be extrapolated for thousands of years and be absolutely sure they will apply to the thermally formed oxide. The point is, if DOE is going to use the titanium in a heavily oxidized (1100F) condition, and did not run corrosion or other tests on material in that condition, they have hardly met a reasonable expectation for testing and verification of the assumptions they are making.

Thermal stress relieving in air (a slightly oxidizing gas or fuel fired furnace) also adds a risk that overall slightly reducing conditions are inadvertently created or that local areas of the furnace have a reducing atmosphere due to inadequate circulation in the furnace, resulting in hydrogen entering the titanium.

DOE has failed to conduct a test of the proposed combination of materials to demonstrate the extent of stress relief that will be obtained with this combination of materials and thermal conditions. DOE has failed to provide proper basic procedures for the proposed stress relief. DOE has failed to assess the effects of stress relief procedure as described on the formation of surface oxide on the material or the resistance of that oxide to long term corrosion in relevant environments. DOE has failed to adequately consider the risks of distortion resulting from stress relief. DOE has failed to describe the need for thermocouples placed on the part to monitor the actual metal temperature as opposed to the furnace temperature, which can vary significantly over a component of the size and configuration of the drip shield. DOE has failed to provide technical criteria for placement of thermocouples and insulation of the thermocouples from the furnace atmosphere to be confident that actual temperatures of the metal part are being recorded.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE’s position that the proposed technique for stress relief, described in SAR Subsection 2.3.6.8.3 and similar subsections, will reduce residual stresses by about 50% and that this is sufficient to ensure that SCC of the Grade 29 titanium or hydride formation in the Grade 7 titanium cannot occur. DOE has failed to adequately consider secondary effects such as the property differences between the two metals, how the proposed ERTi-28 weld metal will respond to the heat treatment, distortion, and hydrogen pick-up. Overall, use the proposed stress relieving treatment is not adequately evaluated or demonstrated and so cannot be relied upon to behave as required for post-closure performance purposes. Specifically, the residual stresses have not been demonstrated to eliminate the risk of SCC to Grade 29 titanium or of hydride migration and formation in Grade 7 titanium. Failure due to residual stresses from either mechanism would lead to preferential paths by which water could contact waste packages, resulting in degradation of those packages by corrosion, release of radionuclides and consequent radiological impacts on the RMEI. Thus, SAR Subsection 2.3.6.8.3 and similar subsections do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's

other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-126 - PROPERTIES OF DISSIMILAR METAL WELD JOINTS BETWEEN GRADE 29 AND GRADE 7 TITANIUM

1. A statement of the contention itself

SAR Subsection 1.3.4.7.7 and similar subsections describe the drip shield system and refer to SAR Table 1.3.4-5 where it is stated that, for Titanium Grade 7 to Titanium Grade 29 welds, Titanium Grade 28 filler material (ERTi-28) shall be used. There is no reference to an actual demonstration of welding and testing this combination of metals, there is insufficient information in the LA to demonstrate that these welds will behave mechanically as assumed in the TSPA, and in particular, there is a failure to consider that these unknown weld properties will lead to unanticipated locations of weld failures that could lead to early failure of drip shields due to external loads from rockfall.

2. A brief summary of the basis for the contention

Use of ERTi-28 filler metal will result in a weld metal composition with mechanical and corrosion properties that are not adequately evaluated for joining the Grade 29 titanium structural members to the Grade 7 titanium water diversion surface (WDS) material, so such welds cannot be relied upon to behave as anticipated or required or to function in their required role for post-closure performance purposes.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. This contention alleges non-compliance with these

regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The LA assumes that because ERTi 3Al-2.5V-0.1Ru (Titanium Grade 28) is intermediate in Al and V content between Ti 6Al-4VELI-0.1Ru (Titanium Grade 29) and unalloyed Titanium 0.15Pd (Titanium Grade 7) that it is appropriate for use as a weld filler between the two grades and that it is the optimum choice of filler metal.

In any event, this combination of materials needs to be welded and the welding procedures qualified and mechanically tested, and then the specific welded joints need to be tested under appropriate corrosion conditions and under conditions where hydrogen may be present (from welding or heat treating operations) or introduced into the metal near the joint before this combination of materials can be considered as the right solution.

Strength Issues

The strength of the Titanium Grade 28 weld metal will vary across the weld, ranging from something approaching Grade 29 strength to something somewhat higher than Grade 7 strength, with the values obtained being very dependent on the welding process, sequence of weld beads and the welding techniques utilized.

Overall, use of Titanium ERTi-28 as a weld filler will result in a weld metal composition with mechanical properties that are not adequately evaluated and so cannot be relied upon to behave as expected and required for post-closure performance purposes.

No evaluation of how such welds would fail under external loads like a rock fall has been made by model testing or finite element analysis (FEA) (indeed, there is inadequate information in the LA on the drip shield design to even consider such analysis). Specifically, SAR

Subsection 2.3.4.5.3.1 suggests that the drip shield will continue to function after its structural collapse, because it will settle over the waste packages, but retain water diversion integrity. Because the weld strength will be significantly higher than the Grade 7 WDS material, a likely failure mechanism will be to tear through the WDS material, opening pathways for seepage water to fall on the waste package.

Failure of welds, either through corrosion or due to impacts such as those associated with seismic events or rock fall, would lead to preferential paths by which water could contact waste packages, resulting in degradation of those packages by corrosion, release of radionuclides and consequent radiological impacts on the RMEI.

Stress Relief Issues

DOE has not demonstrated its assumption that stress relieving will reduce residual stresses by about 50% across the dissimilar metal weld. Because the yield strength (YS) of Grade 29 is roughly 2.7 times the YS of the Grade 7, exacerbated by even higher Grade 29 yield strength ratios at elevated temperatures, it is not at all clear that the stress relieving will accomplish the objective of reducing residual stresses adjacent to the weld as much as hoped.

AWS A5.16 provides no specific guidance for selection of filler metals between Grade 7 and Grade 29. The user must consider the questions of strength and corrosion properties.

AWS recently published G2.4/G2.4M:2007, "Guide to the Fusion Welding of Titanium and Titanium Alloys." (*See* American Welding Society AG2.4/G2.4M "Guide to the Fusion Welding of Titanium and Titanium Alloys" (ANSI approved 09/20/2006)). In Section 7.2 covering filler metals, the Guide states the following:

> Joints between all-alpha unalloyed titanium and alpha-beta alloys such as Grade 5, 9 and 23 are more susceptible to hydrogen problems than joints between two alpha or two alpha-beta materials. This is because hydrogen solubility in the beta phase is much higher than in the alpha phase. Hydrogen from welding dissolved

> in the beta phase may migrate to the alpha phase where lower solubility causes precipitation and formation of titanium hydrides, which can lead to severe embrittlement or delayed cracking. Hydrogen charged into the materials due to corrosion reaction may have a similar effect. Joints between low and high alloy grades (*e.g.* unalloyed Grade 2 joined to Ti 6Al-4V) are not recommended due to possible hydrogen embrittlement at the fusion line.

Grade 29 is analogous to Grade 23 (Ti 6Al-4VELI) and Grade 7 to Grade 2 in this discussion (Grade 7 is the same as Grade 2 except for the added palladium, and Grade 29 to Grade 23 with added palladium). Although an aluminum gradient may help in the dissimilar metal joints in the drip shield, the Grade 29 and the weld metal will both be Alpha-Beta titanium alloys. Hydrogen solubility in the Beta phase is significantly higher than in the Alpha phase.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

As explained above, SAR Subsection 1.3.4.7.7 and similar subsections, refer to SAR Table 1.3.4-5 where it is stated that for Titanium Grade 7 to Titanium Grade 29 welds, Titanium Grade 28 filler material shall be used. However, use of this filler will result in a weld metal composition with mechanical and corrosion properties that are not adequately evaluated, have not even have been demonstrated, nor considered in analysis of failure modes of drip shields under external loading like rock fall, and so cannot be relied upon to behave as hoped for or required for post-closure performance purposes. The weld metal in these joints will most likely have the lowest resistance to corrosion of any weld or material in the drip shield system, but DOE has not even considered it in corrosion testing. This means that there is a failure to comply with 10 C.F.R. § 63.113, as this requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Specifically, there is a failure to comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with

Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-127 - HYDROGEN AND ERTI-28 FILLER METAL FOR WELDED JOINTS BETWEEN GRADE 29 AND GRADE 7 TITANIUM

1. A statement of the contention itself

SAR Subsection 1.3.4.7.7 and similar subsections, which describe the drip shield system, refer to SAR Table 1.3.4-5 where it is stated that, for Titanium Grade 7 to Titanium Grade 29 welds, Titanium Grade 28 filler material (ERTi-28) shall be used, with the objective of reducing the aluminum gradient across the weld as a means to mitigate hydrogen induced delayed cracking issues in these welds, but DOE's failure to include adequate controls on the use of such techniques or to qualify welding procedures and prepare samples to demonstrate that the aluminum gradient concept is truly valid may result in welds that fail to perform as hoped and that are not adequately evaluated for joining the Grade 29 structural members to the Grade 7 Water Diversion Surface (WDS), so such welds cannot be relied upon to behave as anticipated or required for post-closure performance purposes, and could lead to early failure of drip shields.

2. A brief summary of the basis for the contention

The LA incorrectly assumes that because the aluminum and vanadium concentrations in Titanium Grade 28 are intermediate between those in Titanium Grades 7 and 29 that it is the optimum material for use as a filler metal in welds relating the two materials. DOE fails to consider the welding techniques needed to optimize the aluminum gradient and does not address the issue that an inadequately controlled welding technique may adversely affect the integrity of such welds in ways that would be detrimental to post-closure safety.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The LA incorrectly assumes that because ERTi 3Al-2.5V-0.1Ru (Titanium Grade 28) is intermediate in Al and V content between Ti 6Al-4VELI-0.1Ru (Titanium Grade 29) and unalloyed Titanium 0.15Pd (Titanium Grade 7) that it is designed for use as a weld filler between the two grades and that it is the optimum choice of filler metal. However, this is not the case.

Corrosion Issues

The water diversion surface of a drip shield is composed of Titanium Grade 7, which has 0.15 nominal Pd, whereas the structural members are Grade 29, which has 0.10 nominal ruthenium content. However, ruthenium is only about half as potent on a weight basis as palladium in providing added corrosion resistance to the corresponding titanium base alloy. Thus, the structural components contain about 1/3 of the equivalent concentration of the corrosion enhancing platinum group metal addition as compared to the water diversion surface and can be expected to have lower corrosion resistance.

Titanium ERTi-28 filler metal contains the same concentration of ruthenium as the Grade 29 structural material, but because of lower aluminum content welds made with ERTi-28 filler metal are expected to have somewhat better corrosion resistance than Grade 29, offset by the fact that deposited weld metal normally has lower resistance to general corrosion than wrought material of similar composition. Thus, it is not clear in the case of welds to Grade 29 made with ERTi-28 filler metal which has better corrosion resistance.

Note that this also suggests that weld metal in the water diversion surface will corrode faster than the adjacent Grade 7 base metal. Grade 7 weld metal exposed to seepage water is likely to corrode faster than base metal of the same nominal composition.

It would be desirable to use a filler metal with higher equivalent Pd or Ru than the adjacent base materials to attain comparable corrosion performance, but material selections were limited to commercially available grades as listed in ASTM Specifications with no consideration given to optimizing composition for performance and cost (*e.g.*, selection of a filler metal with higher Pd and WDS base material with slightly lower Pd would better match corrosion performance between the two elements of the structure).

Thus, the weld metal will have a lower corrosion resistance than the Grade 7 water diversion surface and it is probable that corrosion resistance will also be lower than for the adjacent Grade 29 structural members.

The use of palladium-enhanced filler metal (ERTi-7) is suggested in AWS A5.16-2007 (American Welding Society "Specification for Titanium and Titanium-Alloy Welding Electrodes and Rods, AWS A5.16/A5.16M" (01/01/2007)) for welding Grades 16 or 26 (mechanically comparable Ru enhanced grades with 1/3 the ruthenium equivalent of Grade 7) as an alternate for reasons of filler metal availability, but selected because of anticipated better corrosion resistance than Grades 16 or 26. The use of a ruthenium-enhanced filler metal to weld to a palladium-enhanced base metal, although it appears feasible from a weldability perspective, has not been demonstrated in significant industrial service (because the corrosion performance is expected to be inferior to welds made with ERTi-7) nor does it appear to have been evaluated in the LA. The assumption that Pd and Ru are interchangeable in welding of these alloys has not been demonstrated in industry or in the LA.

If the corrosion rates of the weld metal are much greater than the adjacent base metal, there is a risk that the weld metal will become active galvanically and corrode even more rapidly, exacerbated by the unfavorable area effect where the large adjacent surface area becomes the cathode to the weld metal’s anodic behavior. Under extended exposure, it is not clear if such a reaction would generate hydrogen on the adjacent base metal surface or how much of that hydrogen would enter the titanium, or if it would contribute to embrittling hydride formation.

Stress Relief and Hydrogen Issues

The assumption that stress relieving will reduce residual stresses by about 50% across the dissimilar metal weld has not been demonstrated. Because the yield strength (YS) of Grade 29 is roughly 2 1/2 times the YS of the Grade 7, exacerbated by higher Grade 29 yield strength ratios at elevated temperatures, it is not at all clear that the stress relieving will accomplish the objective of reducing residual stresses adjacent to the weld as much as is assumed by DOE.

Hydrogen tends to accumulate in areas of high residual stress and when the concentration exceeds the solubility limit of the Alpha or Beta crystalline structure, embrittling hydrides can be formed.

Additionally, despite its lower aluminum content, Titanium Grade 28 as weld metal does not make the adjacent Grade 7 immune to hydrogen embrittlement. There appears to be an assumption that the dissimilar metal weld made with ERTi-28 is immune to hydrogen effects because of the lower ERTi-28 aluminum content or the reduction of the gradient of aluminum composition between the two materials. However, it is the presence of the second phase beta microstructure material (in both Grade 29 and welds made with ERTi-28 filler metal) adjacent to Alpha microstructure (in Grade 7) material that generates the issue with welds between these materials. Hydrogen dissolved in the beta material can migrate to the alpha material, where it can precipitate as titanium hydrides due to the lower solubility in the alpha material.

AWS A5.16 provides no specific guidance for selection of filler metals between Grade 7 and Grade 29. The user must consider the questions of strength and corrosion properties. Use of ERTi-7, for example, or designing the Grade 29 out of the system may have been a better choice.

AWS recently published G2.4/G2.4M:2007, "Guide to the Fusion Welding of Titanium and Titanium Alloys." 1st Edition, ANSI approved September 20, 2006. In Section 7.2 covering filler metals, the Guide states the following:

> Joints between all-alpha unalloyed titanium and alpha-beta alloys such as Grade 5, 9 and 23 are more susceptible to hydrogen problems than joints between two alpha or two alpha-beta materials. This is because hydrogen solubility in the beta phase is much higher than in the alpha phase. Hydrogen from welding dissolved in the beta phase may migrate to the alpha phase where lower solubility causes precipitation and formation of titanium hydrides, which can lead to severe embrittlement or delayed cracking. Hydrogen charged into the materials due to corrosion reaction may have a similar effect. Joints between low and high alloy grades (*e.g.* unalloyed Grade 2 joined to Ti 6Al-4V) are not recommended due to possible hydrogen embrittlement at the fusion line.

Grade 29 is analogous to Grade 23 (Ti 6Al-4VELI) and Grade 7 to Grade 2 in this discussion (Grade 7 is the same as Grade 2 except for the added palladium and Grade 29 to Grade 23 with added palladium). Although an aluminum gradient may help in the dissimilar metal joints in the drip shield, the Grade 29 and the weld metal will both be alpha-beta titanium alloys.

Challenge to Validity of Aluminum Gradient in Mitigating Hydrogen Effects

DOE relies on the referenced Waisman papers (Waisman, J.L., Toosky, R. and Sines, G. (08/1977) "Uphill Diffusion and Progressive Embrittlement: Hydrogen in Titanium," METALLURGICAL AND MATERIALS TRANSACTIONS A, Vol. 8A, No. 8 at 1249- 1256, DIRS 177383; and Waisman, J.L., Sines, G.; and Robinson, L.B. (04/1973), "Diffusion of Hydrogen in Titanium Alloys Due to Composition, Temperature, and Stress Gradients," METALLURGICAL AND MATERIALS TRANSACTIONS B, Vol. 4, No. 4 at 291-302 to support the selection of Grade 28 filler metal for weld joints between Grade 7 and Grade 29 as a means to provide a reduced aluminum gradient between the two alloys to reduce the effects of "uphill hydrogen migration" that is acknowledged by DOE as a source of preferential formation of titanium hydrides in areas of high residual stress associated with welding, in turn leading to delayed cracking of these dissimilar metal welds.

If DOE's position that aluminum gradient is a significant control on hydrogen migration is valid, the effect will be significantly affected by welding technique. Specifically, depending on bead sequence relative to the Grades 7 and 29 sides of the joint, the gradient could be significantly altered. DOE failed to verify this by making such comparisons.

Specifically, a sample produced by first "buttering" (a welding technique employed in dissimilar metal welding where a filler metal of a selected composition is used to create a layer of different chemistry on the original surface) the Grade 29 weld preparation surface with ERTi-28 filler metal, then buttering over that pass, again with ERTi-28, and repeating that with ERTi-7, and finally welding the buttered surface to the Grade 7 using ERTi-7 would produce a lower aluminum gradient than would be achieved by welding Grade 7 to Grade 29 directly using an uncontrolled welding sequence with ERTi-28 alone.

A comparison of samples prepared each way with possibly samples welded with ERTi-7 and ERTi-29 alone would give a range of aluminum gradients that could be tested in environments where hydrogen was artificially increased in the materials (for example, by galvanic charging or by using welding shielding gas slightly contaminated with water, or by welding on cold surfaces, or by welding on imperfectly cleaned surfaces).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's position as articulated in SAR Subsection 1.3.4.7.7 and similar subsections that use of ERTi-28 for welding Grade 29 titanium to Grade 7 titanium will mitigate hydrogen problems associated with the dissimilar welds. As explained above, SAR Subsection 1.3.4.7.7 and similar subsections refer to SAR Table 1.3.4-5 where it is stated that for

Titanium Grade 7 to Titanium Grade 29 welds, Titanium Grade 28 filler material shall be used. However, use of this filler will result in a weld metal composition with mechanical and corrosion properties that are not adequately evaluated, nor considered in analysis of failure modes of drip shields under external loading like rock fall, and so cannot be relied upon to behave as required for post-closure performance purposes. This means that there is a failure to comply with 10 C.F.R. § 63.113, as this requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-128 - NUCLEAR CODE AND FABRICATION QUALITY ASSURANCE STANDARDS

1. A statement of the contention itself

SAR Subsection 1.3.2.7 and similar subsections, and reference document "Drip Shield and Waste Package Emplacement Pallet Design Report, 000-00C-SSE0-00100-000-00B" (08/09/2007), LSN# DN2002459185, Para 6.2.4 at 20, and SAR Table 1.3.2-5 make reference to sections of the ASME Code, various Nuclear Codes and other standards to guide drip shield fabrication that DOE proposes to use but the cited codes and standards do not provide adequate information to evaluate the conceptual design or to specify subsequent detailed design, fabrication, or quality assurance requirements necessary to build drip shields.

2. A brief summary of the basis for the contention

The specifications listed have impressive titles, but are not complete or sufficiently applicable to guide and limit the design and fabrication of the titanium drip shields because they fail to provide adequate information for evaluation of the conceptual design presented, and they are not sufficient to guide eventual detailed design, fabrication, or quality assurance requirements.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The drip shield specification is inadequate and unclear. DOE refers to non-applicable nuclear specifications in the hope that it will somehow convince readers that everything will be excellent.

DOE fails to provide a sufficient project specific requirements in Specification "Waste Package Fabrication, 000-3SS-DSC0-00100-000-00B" (03/13/2007), LSN# DN2002380114 to cover important issues related to material and fabrication, addressing key considerations such as scrap used for ingot production, melting processes, mill processing, controls on the minimum levels of Pd required, plate surface quality requirements, bend testing to verify clean, free of oxygen rich layer, *etc*.

DOE fails to describe a plan for weld quality controls specific to each type of weld in the system. Without such details, evaluation of weld design concepts is impossible.

For example, the water diversion structure (WDS) welds are specified to be full penetration welds, checked by radiography. However, structural attachment welds are likely to be fillet welds where radiography is not applicable. DOE does not state if they are to be intermittent welds or continuous seal welds or to require such steps as fit-up inspection, visual, and penetrant inspection, or even ultrasonic inspection.

The original inquiry allows gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), and manual metal arc (MMA) welding. MMA is not being used anywhere for titanium welding. GTAW is most commonly used in industrial and aerospace applications for detailed welding. Excluding manual GTAW eliminates a reasonable way to make tack welds, usually a necessary part of every fabricated weldment. GMAW is used on titanium, usually for specific lower quality requirements, although interest from the military for ground vehicles may provide the needed experience to make the process viable for higher quality applications. Excluding options like electron beam (EBW) and laser (LAW) eliminates some potentially cost saving and extremely high quality welding processes. Overall, the original inquiry demonstrates that a detailed strategy for welding titanium to a standard appropriate for meeting safety requirements has not been developed.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The specifications and the documents referenced to guide the design, fabrication, and quality control activities of the drip shield as discussed in SAR Subsection 1.3.2.7 and similar subsections are inadequate. Inadequate specifications make evaluation of the drip shield design and performance impossible. Specifically, SAR Subsection 1.3.2.7 and similar subsections fail to comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

NEV-SAFETY-129 - EARLY FAILURE MECHANISMS ASSOCIATED WITH TITANIUM FABRICATION

1. A statement of the contention itself

SAR Subsection 2.3.6.8.4 and similar subsections, which describe drip shield early failure due to manufacturing and handling defects, consider only a limited range of possible defects associated with titanium fabrication and welding (*e.g.*, improper heat treatment, base metal selection flaws, and improper weld filler material) and fail to include many additional defects that could result from fabrication and could lead to early failure of drip shields.

2. A brief summary of the basis for the contention

Titanium welding and fabrication present many opportunities for fabrication errors that are not discussed in the SAR or adequately considered in assessing the effects of features, events and processes (FEPs), specifically those of undetected base metal flaws such as laps or seams, surface contamination, titanium cracking during forming and bending, surface iron contamination, weld contamination due to oxygen or nitrogen, weld contamination due to iron or carbon, missing welds, undersized welds, improper filler metal selection, lack of weld penetration, lack of weld fusion, weld root contamination due to improper or inadequate inert gas shielding, hydrogen induced porosity, high density and tungsten inclusions, hydrogen contamination from stress relief, inconsistent stress relief over the entire structure, localized contamination due to flame impingement on the structure during stress relief, and nondestructive testing and inspection errors, any one of which could occur and escape detection prior to emplacement.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-

compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE does not adequately address numerous potential fabrication defects including undetected base metal flaws such as laps or seams, surface contamination, titanium cracking during forming and bending, surface iron contamination, weld contamination due to oxygen or nitrogen, weld contamination due to iron or carbon, missing welds, undersized welds, improper filler metal selection, lack of weld penetration, lack of weld fusion, weld root contamination due to improper or inadequate inert gas shielding, hydrogen induced porosity, high density and tungsten inclusions, hydrogen contamination from stress relief, inconsistent stress relief over the entire structure, localized contamination due to flame impingement on the structure during stress relief, and nondestructive testing and inspection errors.

Titanium base metals can exhibit numerous types of flaws or substandard characteristics. For example, excessive surface oxygen contamination causes a low ductility surface layer that can impair forming and other fabrication operations, add to weld metal oxygen, and lead to premature equipment failures in service, including static service where there are sudden loads or deformation imposed on the structure.

Depending on the ingot melting methods utilized, there can be composition variances and inclusions in the material. Improper hot working (to make plate and other mill products) can leave undetected laps or seams in the material. Inadequate acid pickling of plate can leave an excessive oxygen-rich surface zone that exhibits low ductility and can lead to cracking during fabrication or in service under loads that cause significant strains.

Oxygen, nitrogen, iron, carbon, and hydrogen are important to the properties of titanium metal and titanium welds. For example, the strength of various unalloyed titanium grades is determined by minute differences in the content of these elements.

The mechanical and corrosion properties of titanium welds are very dependent on how the details of cleaning and shielding procedures are applied. This is because oxygen, nitrogen, iron, carbon, and hydrogen can all enter titanium welds from sources other than the filer metal during welding. In essence, unlike most other materials, important titanium strengthening alloying elements come from the welding atmosphere, not necessarily from the welding filler metal. These elements are referred to as "contaminants" in titanium welding, and a weld with excessive amounts of these elements is referred to as "contaminated."

AWS recognizes the importance of these elements by requiring the chemistry of filler metals to be lower in these elements than the corresponding base metals for which they are designed. For example, AWS assumes that properly executed titanium welding will still increase the oxygen level of the weld by about 300 ppm, exclusive of the effects of dilution from higher oxygen base metal, so filler metal oxygen ranges are lower than typical corresponding wrought materials.

It follows from the above discussion that the quality of a titanium weld is vitally dependent on both the procedure used and the exact detail of how the procedure is applied. Much of the quality is dependent on the welder’s understanding of the contamination problem and instant recognition of the sources. Loss of control can come from numerous sources, none of which are addressed in DOE’s FEP analysis.

For example, welding shielding gas can be contaminated when it is received, can become contaminated by leaks in the distribution system, and can be contaminated by water leaks in a welding torch. At low levels, such contamination may be difficult to detect, even where very rigorous controls are imposed. Inadequate cleaning of titanium surfaces or contamination from handling after cleaning, or airborne material that settles on the titanium can lead to weld contamination. Welding filler metal may have a minor amount of drawing compound left even after careful manufacture. Drafts in the welding shop can disrupt inert gas shielding during welding. Even an insect attracted to the light of the welding arc can cause problems. Detection of many of these problems depends on the skill and training of the welder, and as importantly on the attitude of the management of the welding shop toward quality and production rate.

There is no standardized or universally accepted test for detecting contaminated titanium welds. Surface color (oxide color) is sometime used as a surrogate test for weld contamination and is a good indication of the weld's history after solidification and partial cooling. Weld metal hardness is a better indicator of the weld contamination that might occur during its molten state, but methods of practical hardness testing utilizing ultrasonic and eddy current devices have yet to reach industrial acceptance or use.

DOE ignores the most common titanium welding defect, contamination, in its TSPA. Further, there is no standardized or accepted test for detecting contaminated titanium welds, and DOE fails to provide a plan for dealing with them or an evaluation of their significance for long-term safety. DOE ignores numerous other potential fabrication defects, assuming that a rigorous quality control system will prevent them. While a competent or dedicated fabricator can do a very good job on a project of this kind, the assumption that these types of defects will all be detected is wishful thinking.

In SAR Subsection 2.3.6.8.4.3.1 at 2.3.6-80, DOE states that "[s]ince the drip shield will be fully stress-relief-annealed (Section 1.3.4.7), weld flaws will not act as possible stress corrosion cracking locations. Thus, drip shield fabrication weld flaws are not further considered (SNL 2007d, Section 6.2.3)."

Stress relieving is not capable of eliminating flaws and while it may have some benefits in reducing risks of stress corrosion cracking (SCC), this has not been demonstrated by comparing welded and stress-relieved samples with as-welded samples of joints of whatever designs are being considered.

In "Analysis of Mechanisms for Early Waste Package/Drip Shield Failure, ANL-EBS-MD-000076 REV00" (06/29/2007), LSN# DN2002451287, Section 6.2.3 at 6-15, DOE dismisses weld joint design – "problems with the design of the joint weld for the waste package outer corrosion barriers and the drip shields are not expected" due to the "significant development and testing effort [that] will have gone into the design of the final joint closure." However, DOE provides no detail as to the design envisioned, particularly for the structural joints and joints between the water diversion surface and the structural members. Some of these joints would appear to be suited to fillet welds, or intermittent fillet welds, but such joint details can increase susceptibility to cracking under some load conditions and to crevice corrosion under other conditions.

In DN2002451287, Section 6.2.3, at 6-15, DOE also states "improper weld-flux material is screened from further evaluation . . . [because] welds in the waste package outer corrosion barriers and drip shields will employ a welding method . . . that does not use weld-flux material."

However, DOE does not consider the analogous risks of weld contamination from inadequately cleaned base or filler material, inadequate shielding gas, or inadequate application of shielding gas to welding shielding and purging.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's assumption identified in SAR Subsection 2.3.6.8.4, and similar subsections, that there will be minimal defects associated with fabrication of the titanium drip shields, and as a result the LA fails to address the effect these fabrication issues might have on the effectiveness of the drip shields and the dose to the RMEI. These subsections do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This

vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-130 - DRIP SHIELD EMPLACEMENT PLAN, EQUIPMENT, AND SCHEDULE

1. A statement of the contention itself

SAR Subsection 1.3.4 at 1.3.4-1 identifies two engineered components within the repository drift that are important to waste isolation – the waste package and the drip shield – and the license application relies on installation of drip shields to prevent exceeding the allowable dose to the RMEI. The drip shields are a new technology that has never been designed in detail, prototyped, fabricated, or installed in any actual application in order to develop a basis for predicted performance or to demonstrate that drip shields can be installed and perform as assumed in the TSPA; therefore, the contribution of the drip shields in the predicted performance of the repository should be ignored in the TSPA or, at a minimum, the no drip shield scenario should be considered as an alternative conceptual model and propagated through the assessment.

2. A brief summary of the basis for the contention

Installation of the drip shields, several decades after placement of the waste in the repository, cannot be assumed to occur because, at a minimum, DOE has failed to identify the features, events and processes that can prevent drip shield installation and DOE has failed to identify the relevant design features of the engineered barrier system.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

General

There are two engineered components within the repository drift that are important to waste isolation: the waste package and the drip shield. *See* SAR Subsection 1.3.4 at 1.3.4-1. In SAR Subsections 1.3.4.7.2 and 1.3.6.1, and other places in the LA, a plan is presented to delay manufacture and installation of drip shields, and more importantly to delay a demonstration that it can even be done, for several decades after waste packages are emplaced as part of closure of the repository. Drip shields would have to be placed using remote equipment, which has not been designed, under difficult underground conditions that include high levels of radioactivity and temperatures, and under conditions where drift degradation due to corrosion of steel components, rockfalls and drift collapse, and other unforeseen conditions might have occurred. The LA assumes that drip shield emplacement will work as envisioned and that no foreseen or unforeseen event will occur in the time period between the placement of waste package and the installation of the drip shields that will prevent or hinder placement of the drip shields. This assumption is simply not credible given the lack of information provided in the LA and the absence of any form of prototype construction, mock-up, or demonstration.

Without proper installation of the drip shields, the proposed Yucca Mountain repository will not perform as modeled in the TSPA and it will not meet the ground water protection standards set forth in 10 C.F.R. § 63.331. DOE has not provided sufficiently detailed design information (*see* SAR Subsection 1.3.4.7 and related sections) to fabricate the drip shields, much less than that required to fabricate drip shields that can or will perform as assumed by the TSPA.

An analysis of DOE's own documentation reveals that without the protection DOE claims the drip shields will provide, the reasonably maximally exposed individual (RMEI) will receive an annual dose of at least 10 times the regulatory standard set forth in 10 C.F.R. § 63.311.

DOE has presented a conceptual plan for remotely placing the drip shields but does not show how it will validate the equipment or develop the techniques and operator skills necessary to do so. Without such a demonstration, it cannot be assumed that the drip shields will be placed over all of the waste packages in the manner assumed in the TSPA. At minimum, the drip shield placement system (gantry, sensors, *etc.*) should be demonstrated numerous times in drifts prior to placement of the first waste packages to demonstrate that it may actually work as planned.

Drip Shield Design

DOE has not designed the drip shield to the point that the design is clear in terms of the titanium mill products to be used for fabrication, any requirements for that material beyond reference to ASTM specifications (i.e., the bare minimum requirements for products), the structural and welding design details envisioned or the methods of fabrication to produce a drip shield meeting the requirements.

DOE has not provided an adequate specification or drawing to describe what requirements the fabricator of the drip shields will necessarily meet, *e.g.*, the dimensional tolerances required for the connector section to work, the shapes and forms for the structural supports, the type of weld (*e.g.* fillet, full penetration, *etc.*) to be used to attach the structural shapes to the water diversion surface, *etc.*

Drip Shield Fabrication

DOE has not presented a credible plan for how it will organize and manage the resources necessary to fabricate the drip shields. Today, there are insufficient specialist titanium subcontractor resources in the United States to fabricate drip shields on the schedule required. The use of subcontract fabricators or a dedicated facility set up specifically to make drip shields have not been compared.

Key manufacturing processes, like welding the Grade 28 to the Grade 7, or the proposed thermal stress relieving, have not been demonstrated or qualified. Titanium welding is widely understood to require special procedures, training, and process controls that are not discussed in the LA at all.

Gantry Design

DOE has not designed the drip shield placement system (gantry, sensors, *etc*.) and has not shown that it can be operated in the repository under normal and off-normal conditions, nor has DOE provided operational procedures for the placement system. Given that a placement system of this type has never been designed or constructed, DOE has not provided the minimum level of design detail necessary to demonstrate that the placement system will perform as assumed in the TSPA. Failure of the gantry system to perform as assumed in the TSPA can result in exceeding the individual and groundwater protection standards. Given the critical importance of the drip shield placement system and the fact one has never been built or evaluated with regard to its performance and reliability, a prototype system should be designed, constructed and operated in order to determine if it can perform as assumed in the TSPA. Until this has been done, the TSPA results reported in the LA are unreliable.

Emplacement Procedures

DOE has failed to demonstrate that it has a real plan for designing, constructing and operating the required emplacement equipment, or that the equipment will work under the conditions anticipated.

Emplacement should be practiced in drifts without waste packages to develop the operating skills needed in the personnel who will actually be involved, and repeated as needed to verify proficiency of the personnel. So that these skills are not lost, placement of drip shields over waste canisters should commence shortly after the beginning of placement of waste packages.

DOE has not presented an operations analysis to show that it can actually install drip shields at the rate required to meet the 10 or 20 year schedule proposed for installation, even assuming there are no unforeseen problems.

DOE has not conducted a credible analysis or identified the feature, events or processes that can or will hinder or prevent placement of drip shields, taking account of those occurring during placement of the waste packages, during the interval between waste package placement and drip shield placement, or during drip shield placement.

For example, DOE concludes that errors in waste emplacement (that could prevent drip shield installation) will not exist at the time of closure because such errors are excluded by regulation (FEP: 1.1.03.01.0A). In fact, DOE has not even identified the types of Category 1 accidents that could impact waste package placement. For example, "Scope of Work for Waste Package Structural Design - Task: TEV Collision With Emplaced 2-MCO/2-DHLW Waste Package" (07/2008), LSN# DEN001602017 was issued after submittal of the LA and recognizes the need to perform an analysis of the impact of a runaway TEV on the integrity of an emplaced waste package. However, the Scope of Work document does not address another obvious concern resulting from such an impact by a heavy moving object – i.e., to dislocate one or more waste packages such that drip shield placement is obstructed by the displaced waste package(s). In the event of this accident scenario, the location of the displaced waste packages could be such that it prevents drip shield installation not only over the displaced waste packages, but also over the waste packages that are further down the same drift, *e.g.*, by obstructing the gantry. DOE has not provided any design information for the equipment necessary to address this FEP. There are other similar FEPs that may occur and have not been assessed by DOE.

Material Resources

DOE has ignored the strain on the material supply industry to provide not only the drip shield materials (titanium, ruthenium, and palladium), but also of the waste package (nickel, chromium, *etc.*), not to mention the spent uranium itself. All these irreplaceable materials are placed out of man's use for the foreseeable future.

Competing Uses of Materials

DOE has not considered competing uses for the raw materials required for the drip shield, or to demonstrate that in the event these resources are required for other projects of national importance, let alone economic importance, it can guarantee that the resources will be available.

Palladium and ruthenium in particular are mined, and mined resources are limited and the exploitation lifetime is finite. Current demand is met in part by recycling. DOE has not demonstrated that these key materials will even be available in the time frame envisioned.

Titanium is widely used in military and aerospace requirements, and also in industrial applications like energy, mining, chemical processing, and a host of other evolving uses. Although titanium is abundant, supply has remained in balance with demand within any decade in recent history. DOE has not shown that the requirements of a one-time use like drip shields will be satisfied in the face of these competing continuing applications.

Funding

The cost of drip shields is likely to rise relative to inflation and will most likely be impacted by speculation in at least palladium and ruthenium as the project grows closer to realization. DOE has not demonstrated how it will convince Congress to allocate the funds for this part of the project so long after it has been initiated.

Drift Deterioration/Collapse

DOE proposes to allow several decades to pass before a drip shield is even fabricated, let alone installed. DOE assumes that no anticipated or unanticipated event can or will occur either during this time interval that will hinder or prevent placement of the drip shields or during the act of installing the drip shields except for a low probability scenario of one misplaced drip shield due to operator error. Other contentions (NEV-SAFETY-123, NEV-SAFETY-136, and NEV-SAFETY-173) specify rock fall and drift collapse scenarios that can occur prior to repository closure, including prior to drip shield installation. In general, the amount of deterioration of the infrastructure that drip shield installation relies upon, *e.g.*, electrical supply/distribution system, the carbon steel rails, *etc*., has not been determined and provision for repair or use of alternative systems has not been provided.

DOE has not provided an alternate plan for conditions where deterioration has progressed to the point that assumptions of drift integrity, rail integrity and waste package support system integrity are such that the original drip shield emplacement plan is unworkable.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the DOE assumption, in SAR Subsection 1.3.4.7 and similar subsections, that it can (or will) emplace the drip shields over the waste packages using remote equipment and sensors after several decades of drift deterioration, corrosion of the steel rails and waste package steel support systems, under conditions of dust, moisture, and temperature predicted to exist in the repository at that time of closure, and with limited ability to manually correct placement problems that will inevitably be encountered. If the drip shields cannot be placed over any significant number of waste packages, the TSPA model is invalid and the dose to the RMEI will exceed regulatory standards. These considerations mean that the LA does not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many

thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(r) Lack of Description of Engineered Barrier System Components and Operations

NEV-SAFETY-131 - ROCK DEBRIS REMOVAL

1. A statement of the contention itself

SAR Subsection 1.3.4.4 and similar subsections, which discuss the design and performance of the waste emplacement areas of the repository, fail to include sufficient detail to demonstrate that consideration has been given to the potential need to remove rock debris from around the waste packages prior to removal of the waste packages, if necessary, and/or installation of the drip shields, and as a result, the TSPA-LA assumptions relating to drip shield emplacement and effectiveness of the EBS are unfounded.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that retrieval of waste packages will be a simple reversal of emplacement using the TEV and that placement of the drip shields will be routinely achieved using the Drip Shield Gantry. For this to occur, the waste packages must be aligned within specific tolerances and there must not be sufficient debris from rock falls lying on top of or adjacent to the waste packages to reduce or eliminate the space allowed for in these tolerances.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.4.2 at 1.3.4-15 states that in order to remove or repair parts of the permanent ground support system, it "would likely require removal of all waste packages from the affected drift prior to any repair work." The subsection describes how the repair or removal and replacement of the ground support would be achieved once the waste had been removed; however, there is no mention of how the waste packages would be removed or the conditions to be encountered during the removal. Presumably, the need to repair or replace a component of the ground support system would be triggered by a significant roof fall, which suggests that, at a minimum, the waste package located immediately below the affected area would be covered in debris. Also, the debris could be expected to damage the waste package as large rock falls in bolted drifts in mines have been known to completely cover and significantly damage mining equipment such as bolter jumbos.

SAR Subsection 1.3.4.4.2 at 1.3.4-15 also states that "[b]enefits of repairs and replacements would be weighed against potential radiological exposures and other operational concerns specific to the situation." On the face of it, this statement implies that some failures of components of the ground support system may not be addressed, which further suggests that minor rockfalls will be left in place. There is no apparent recognition of the fact that these rockfalls could interfere with the emplacement of the drip shields.

This lack of information has a critical impact on the evaluation of repository performance and safety using the TSPA-LA, because the drip shields are components of the EBS and are classified as important to waste isolation (ITWI) during the post-closure. Therefore, any condition that can be identified as potentially interfering with installation of the drip shield would, in turn, compromise the EBS.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 1.3.4.4 and similar subsections, which discuss the design and performance of the waste emplacement areas of the repository, because they fail to include sufficient detail to demonstrate that consideration has been given to the potential need to remove rock debris from around the waste packages prior to removal of the waste packages, if necessary, and/or installation of the drip shields, and as a result, the TSPA-LA assumptions relating to drip shield emplacement and effectiveness of the engineered barrier system are unfounded. By failing to address these conditions, SAR Subsection 1.3.4.4 and similar subsections fail to comply with 10 C.F.R. § 63.114(a) which requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment.

NEV-SAFETY-132 - TEV DESCRIPTION

1. A statement of the contention itself

SAR Subsection 1.3.3.5.1.1 and similar subsections, which identify the Transport and Emplacement Vehicle (TEV) as the crane-rail-based transport assembly that moves waste packages on emplacement pallets from surface facilities to the emplacement drifts, fail to include sufficient detail to determine whether the TEV will fulfill the requirements that the TSPA-LA places on it, and as a result, the TSPA-LA assumptions relating to waste package emplacement and effectiveness of the engineered barrier system are unfounded.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that waste packages are emplaced within specified tolerances and in conformance with other engineering requirements. The lack of design information on the TEV means that there is no assurance that this can be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.3.5.1.1 identifies the TEV as a crane-rail-based transport assembly that moves waste packages on emplacement pallets from surface facilities to the emplacement drifts. The TEV is described at page 1.3.3-30 as "a first-of-a-kind application of existing technology." However, the description that it is an application of existing technology is misleading, as all that is said is that "most components of the TEV are based on commercially available equipment," which implies adaptation of commercially available items and leaves some items to be developed specifically for this application. Also, development of the design of the TEV is at a very early stage, as it is stated that "[c]odes and standards have been evaluated and design requirements and testing specifications are being developed." This means that not only is there, as yet, no engineering design for the TEV, but that some of the requirements to be achieved through that design have yet to be defined.

This lack of design information has a critical impact on the evaluation of post-closure safety using the TSPA-LA, because the TEV has the primary function of transporting waste packages to the repository subsurface for emplacement (*see* SAR Subsection 1.3.3.5, at 1.3.3-27). Precise emplacement is required because "[w]aste package emplacement geometry and thermal loading may affect the scale at which condensation caps form (over waste packages, over panels, or over the entire repository), and the extent to which 'shedding' will occur as water flows from the region above one drift to the region above another drift or into the rock between drifts." SAR Table 2.2-5, at 2.2-259. In the absence of a TEV design, or even a complete set of design requirements, and bearing in mind that this is a unique, first-of-a-kind vehicle required to operate remotely in a hot, spatially restricted, high radiation, underground environment, it is not possible to have any confidence that the precise emplacement geometry required on thermo-hydrological grounds can be achieved. Therefore, water flows in the vicinity of drifts, including seepages onto waste packages, may not be as assumed in the TSPA-LA, with potential implications for corrosion and radionuclide release and transport that would, in turn, affect assessed radiological impacts on the RMEI.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.3.5.1.1 and similar subsections, which identify the Transport and Emplacement Vehicle (TEV) as the crane-rail-based transport assembly that moves waste packages on emplacement pallets from surface facilities to the emplacement drifts, because they fail to include sufficient detail to determine whether the TEV will fulfill the requirements that the TSPA-LA places on it, and as a result, the TSPA-LA assumptions relating to waste package emplacement and effectiveness of the engineered barrier system are unfounded. By failing to include sufficient detail, SAR Subsection 1.3.3.5.1.1 and similar subsections fail to comply with 10 C.F.R. § 63.114(a) which requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment.

NEV-SAFETY-133 - DRIP SHIELD GANTRY DESCRIPTION

1. A statement of the contention itself

SAR Subsection 1.3.4.7 and similar subsections, which identify the Drip Shield Gantry as the crane-rail-based transport assembly that moves the drip shields from surface facilities to the emplacement drifts and into position covering the waste packages, fail to include sufficient detail to determine whether the Drip Shield Gantry will fulfill the requirements that the TSPA-LA places on it, and as a result, the TSPA-LA assumptions relating to drip shield emplacement and effectiveness of the engineered barrier system are unfounded.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that drip shields are emplaced within specified tolerances and in conformance with other engineering requirements. The lack of design information on the Drip Shield Gantry means that there is no assurance that this can be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.7 identifies the Drip Shield Gantry as a crane-rail-based transport assembly that moves drip shields from surface facilities to the emplacement drifts. The Drip Shield component of the EBS is described, at 1.3.4-31, as "a unique component" for which "there are no established industry practices for its design." By extension, the Drip Shield Gantry used to transport the drip shields must necessarily also be unique; however, this fact is not explicitly stated in SAR Subsection 1.3.4.7. SAR Subsection 1.3.4.7.2 at 1.3.4-27 through 1.3.4-29 describes many of the systems and components on the Drip Shield Gantry are being similar to those on the TEV. Consequently, one can assume that , as for the TEV, not only is there, as yet, no engineering design for the Drip Shield Gantry, but that some of the requirements to be achieved through that design have yet to be defined.

This lack of design information has a critical impact on the evaluation of post-closure safety using the TSPA-LA, because the Drip Shield Gantry has the primary function of transporting and placing the drip shields, which are one of the components of the EBS. In the absence of a Drip Shield Gantry design, or even a complete set of design requirements, and bearing in mind that this is a unique, first-of-a-kind vehicle required to operate remotely in a hot, spatially restricted, high radiation, underground environment, it is not possible to have any confidence that the precise emplacement geometry required for the drip shields can be achieved. Therefore, water flows in the vicinity of drifts, including seepages onto drip shields, may not be as assumed in the TSPA-LA, with potential implications for corrosion and radionuclide release and transport that would, in turn, compromise the EBS.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.4.7 and similar subsections, which identify the Drip Shield Gantry as the crane-rail-based transport assembly that moves drip shields from surface facilities to the emplacement drifts where they are installed over the waste packages, because they fail to include sufficient detail to determine whether the Drip Shield Gantry will fulfill the requirements that the TSPA-LA places on it, and as a result, the TSPA-LA assumptions relating to waste package emplacement and effectiveness of the engineered barrier system are unfounded. By failing to include sufficient detail, SAR Subsection 1.3.4.7 and similar subsections fail to comply with 10 C.F.R. § 63.114(a) which requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment.

NEV-SAFETY-134 - RETRIEVAL OR ALTERNATE STORAGE DESCRIPTION

1. A statement of the contention itself

SAR Subsection 1.11.1 and similar subsections, which discuss the approach to retrieval of waste packages from the repository, fail to consider that rockfall debris, breached waste packages and other "off-normal" conditions can be reasonably expected to be encountered in the emplacement drifts, such that retrieval is not simply a reversal of the emplacement process and may require development of specialized equipment.

2. A brief summary of the basis for the contention

The TSPA-LA assumes that retrieval is a simple reversal of the emplacement process and that consideration of "off-normal" conditions will not be necessary when planning for retrieval.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.21(c)(7) requires that the SAR must contain a description of plans for retrieval and alternate storage of radioactive wastes should retrieval be necessary. In addition, the performance objectives for a repository specifically include in 10 C.F.R. § 63.111(e)(1) the requirement that the option of retrievability of any or all waste packages must be maintained for up to 50 years from initiation of waste emplacement. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.11.1 at 1.11-2 states explicitly the belief that:

> operations performed during retrieval are not significantly different than those of operations performed during the preclosure period. The aspects of retrieval as related to subsurface operations closely parallel those of emplacement, so few if any additional hazards are expected to be identified.

This statement is reiterated in slightly different fashion on page 1.11-3 of the SAR where it is stated that retrieval of waste packages would be performed using the Transport and Emplacement Vehicle (TEV) in reverse order to that of emplacement. However, on SAR page 1.11-7, it is recognized that the following events could occur,

- Derailment of the TEV;
- Waste package drop;
- Damage to the TEV by impacts;
- Impact between the TEV and facility structures, equipment, or objects;

These events are dismissed by the statement that "(t)hese same or derivative events might be encountered during normal emplacement operations, so lessons learned during emplacement operations will be documented in retrieval plans and applied in implementing recovery actions during retrieval."

"Recovery" is defined in SAR Subsection 1.11.1 at 1.11-3 as "removing or relocating selective waste packages from the subsurface as a result of concerns related to an off-normal condition," which is a means of avoiding the issue of accounting for such events in their retrieval plans. Such statements indicate that little consideration has been given to retrieval under conditions whereby rockfall debris, misaligned waste packages, or weakened or breached waste packages are encountered that prevent removal of the waste packages using the TEV.

It should be noted that the "retrieval" as defined in 10 C.F.R. § 63.2 includes removal of *any or all* waste packages, and therefore encompasses DOE's "recovery" concept. However, SAR Subsection 1.11 does not provide any plans for "recovery" should it be required. Thus, the SAR does not contain a sufficient description of plans for retrieval and alternate storage.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 1.11.1 and similar subsections, which discuss the approach to retrieval of waste packages from the repository, because they fail to consider that rockfall debris, breached waste packages and other "off-normal" conditions can be reasonably expected to be encountered in the emplacement drifts such that retrieval is not simply a reversal of the emplacement process and may require development of specialized equipment. This means that the LA does not fully comply with 10 C.F.R. § 63.21(c)(7), which requires that the SAR must contain a description of plans for retrieval and alternate storage of radioactive wastes should retrieval be necessary.

NEV-SAFETY-135 - THE VENTILATION DOORS AT THE ENTRY TO THE EMPLACEMENT DRIFTS

1. A statement of the contention itself

SAR Subsection 1.3.5.1.3.3 and similar subsections, which describe the ventilation doors and associated airflow regulators intended to isolated the emplacement drifts from the access drifts and minimize leakage of radiation into the latter drifts during the waste emplacement process, fail to provide sufficient detail to determine whether the doors will fulfill the requirements that the LA places on them and as a result, the LA assumptions relating to the isolation of the emplacement drifts are unfounded.

2. A brief summary of the basis for the contention

The LA assumes that the ventilation doors will provide an airtight seal to minimize the leakage of radiation from the emplacement drifts into the access drifts. The lack of design information on the doors means that there is no assurance that this can be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.5.1.3.3 discusses the turnout bulkheads, emplacement access doors and airflow regulators that are intended to control the flow of ventilation air into the emplacement drifts while waste emplacement in the drifts is progressing. Although the concepts appear to have been thought out, no details are provided to indicate whether the practicality has been assessed. For example, SAR Figure 1.3.5-9 at 1.3.5-49 shows twin doors with the left door (when facing the bulkhead and doors) swinging outward and the right door, inward. This arrangement allows the use of a single door opener with a connecting rod between the doors; however, it will require close tolerances in the alignment of the doors in order for this mechanism to function correctly and seal off the opening.

Other problems can also be identified. For example, SAR Figure 1.3.5-10 at 1.3.5-51 shows the clearance envelope; however, no dimensions are provided. Also, no materials are specified for the compressible vertical gasket seals on the doors shown on SAR Figure 1.3.5-11 at 1.3.5-53. There is no assurance that the material for these seals is stable at predicted temperatures during waste emplacement (50 °C to 70 °C). Further, for all of these seals to function, very close tolerances are required for the closing of the doors which may be difficult to maintain over time. Accumulation of dust on the doors and doorframes could interfere with the ability to close the doors in the manner that meets the tolerance requirements. Without such details being given, there is no assurance that the bulkheads and doors will operate properly.

Another concern is the airflow regulator at the side of the bulkhead. Based on SAR Figure 1.3.5-13 at 1.3.5-57, regulation of the airflow will be by means of a butterfly valve in series with airflow straighteners. However, it is not clear that the shock losses from the expansion and contraction into the regulator and through the damper have been considered in the design. Other interferences with this set-up are precipitation of dust on the damper plate and airflow straighteners which would result in additional constriction of the airflow and additional shock losses. Finally, SAR Figure 1.3.5-10 at 1.3.5-51 provides no information on the inside dimensions of the opening in the bulkheads when the doors are opened. Additionally, the outside dimensions of the TEV are not provided and consequently it is not possible to determine whether the TEV will fit through the ventilation doors.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.5.1.3.3 and similar subsections, which describe the ventilation doors and associated airflow regulators intended to isolated the emplacement drifts from the access drifts during waste emplacement and minimize leakage of radiation into the latter drifts, because they fail to provide sufficient detail to determine whether the doors will fulfill the requirements that the LA places on them, and as a result, the LA assumptions relating to the isolation of the emplacement drifts during waste emplacement are unfounded. Thus, SAR Subsection 1.3.5.1.3.3 and similar subsections do not comply with 10 C.F.R. § 63.114(a), which requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment.

NEV-SAFETY-136 - PHASED GROUND SUPPORT INSTALLATION

1. A statement of the contention itself

SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system in the emplacement drifts, fail to include sufficient detail to determine whether the rock support system will fulfill the requirements that the LA places on it, and as a result, the LA assumptions relating to effectiveness of the geologic and engineered barrier system are unfounded.

2. A brief summary of the basis for the contention

The LA assumes that the emplacement drifts will have a regular circular cross-section that is not significantly modified as a result of the use of a two-stage rock reinforcement and support system. Given the very close fracturing in the lithophysal units that will form the host rock for 85% of the emplacement drifts, there is no assurance that this will be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree

to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.4 discusses the initial and permanent ground support systems for the repository. SAR Subsection 1.3.4.4.1 at 1.3.4-10 states that the initial support system will consist of 1.5-m long Super Swellex-type friction rock bolts together with welded wire mesh installed in the crown only. Later, prior to emplacement of the waste packages, the final support system, which consists of three meters long, Super Swellex-type friction rock bolts together with Bernold sheets will be installed in the crown and walls of the drifts. *See* SAR Subsection 1.3.4.4 at 1.3.4-8.

SAR Subsection 1.3.4.4 at 1.3.4-9 states that the lithophysal rock units contain approximately 5% to 40% void porosity in the form of lithophysae, which average about 10 cm in diameter but range up to 1.8 m in diameter. Also, the lower lithophysal unit is highly fractured, with fracture spacings of a few centimeters and trace lengths averaging about 0.3 m. Based on this characterization of the rock mass, one can expect that upon removal of the initial rock support system there will be significant roof falls that could vary substantially in volume and depth into the roof. Moreover, scaling of the roof and walls before the installation of the final rock support system will exacerbate the unevenness due to spontaneous rockfalls. As a result, it is highly unlikely that the perimeter of the emplacement drifts will be smooth as the LA assumes. This will impact the assumptions concerning the heat transfer into the rock mass surrounding the drifts, the effectiveness of the ventilation system (as the frictional losses will be higher than anticipated), and the effectiveness of the capillary barrier to seepage postulated for the post-closure period. All of these factors could be of significance with respect to the characteristics of water seeping into the emplacement drifts, degradation of waste packages and release of radionuclides.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.4.4 and similar subsections, which discuss the ground support system in the emplacement drifts, fail to include sufficient detail to determine whether the rock support system will fulfill the requirements that the LA places on it, and as a result, the LA assumptions relating to effectiveness of the geologic and engineered barrier system are unfounded. Thus, the LA does not comply with 10 C.F.R. § 63.114(a), which requires the inclusion of information on the design of the engineered barrier system for use in a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113.

NEV-SAFETY-137 - CONSTRUCTION OF THE EMPLACEMENT DRIFTS

1. A statement of the contention itself

SAR Subsection 1.3.4.3 and similar subsections, which discuss excavation of the emplacement drifts, fail to include sufficient detail to determine whether the tunnel boring machine (TBM) will fulfill the requirements that the LA places on it, and as a result the LA assumptions concerning the excavation of the emplacement drifts are unfounded.

2. A brief summary of the basis for the contention

The LA assumes that the emplacement drifts will be constructed to meet specified tolerances and in conformance with other engineering specifications; however, the lack of design information on the TBM means that there is no assurance that these requirements can be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect

compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.3 at 1.3.4-7 and 1.3.4-8, which discusses excavation of the emplacement drifts, states that "(t)he use of a tunnel boring machine for excavating the emplacement drifts assures a correct alignment of the drifts and produces a clean bore that facilitates the installation of the ground supports designed for the emplacement drifts." This statement may be true for hard rock TBM tunnels that have been constructed in much harder and less jointed rock than the Topopah Springs tuff, but is somewhat optimistic and idealized for the Topopah Springs tuff, especially the lithophysal units. It is not uncommon for roof falls to occur on and around TBMs and in extreme cases the TBM can be buried and abandoned in place. Given the close jointing and soft nature of the lithophysal tuff units, it can be expected that the TBMs will encounter difficulties with roof falls. If problems in particular areas of the repository become severe, the decision might be taken to abandon these areas. Based on SAR Figure 1.3.4-2, given that the available areas within the repository footprint that are currently not used for emplacement drifts are mainly within the lithophysal units, especially the upper lithophysal unit, it is quite possible that abandonment of a number of areas becomes necessary and in the extreme case, the ability of the repository to isolate waste becomes compromised.

TBMs perform best in uniform rock conditions. Based on SAR Figure 1.3.4-2 at 1.3.4-68, the TBM(s) at Yucca Mountain will be required to bore through both lithophysal and nonlithophysal units in virtually every emplacement drift in the facility. Because of the difference in the strengths of the lithophysal and nonlithophysal units, it will likely be necessary to change cutters wherever a contact is encountered. Moreover, the potential for unfavorable roof conditions increases at such contacts. SAR Subsection 1.3.4.3 contains no detailed design information on the TBM, so it is impossible to determine whether the considerations discussed above have been considered. Without such information, there is no assurance that the TBM will function as assumed in the LA.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.4.3 and similar subsections, which discuss excavation of the emplacement drifts, because they fail to include sufficient detail to determine whether the tunnel boring machine will fulfill the requirements that the LA places on it, and as a result the LA assumptions concerning the excavation of the emplacement drifts are unfounded. Thus, SAR Subsection 1.3.4.3 and similar subsections do not comply with 10 C.F.R. § 63.114(a), which requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment.

NEV-SAFETY-138 - DESCRIPTION OF THE VENTILATION SYSTEM FOR THE REPOSITORY OPTIONS MADE IN THE TSPA-LA REGARDING WASTE ISOLATION

1. A statement of the contention itself

SAR Subsection 1.3.5.1.3.1 and similar subsections, which describe the intake and exhaust fans for the facility, fail to provide sufficient detail to determine whether the ventilation fans will fulfill the requirements that the LA places on them and as a result, the LA assumptions relating to the isolation of the emplacement drifts during the pre-closure period are unfounded.

2. A brief summary of the basis for the contention

The LA assumes that the intake and exhaust ventilation fans will provide a sufficient airflow to ventilate the emplacement drifts and keep the drift temperatures below 50 °C. The lack of design information concerning air quantities and static pressures to be handled by the ventilation fans means that there is no assurance that the presumed total airflows will be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(6) requires a description of the program for control and monitoring of radioactive effluents and occupational radiological exposures to maintain such effluents and exposures in accordance with the requirements of Section 63.111. 10 C.F.R. § 63.112(e) (part of Subpart E) requires an analysis of the structures, systems and components to identify those that are important to safety. This analysis shall describe the controls that are relied on to limit or prevent potential event sequences or mitigate their consequences including the means to limit the concentration of radioactive material in air and the means to control the dispersal of radioactive contamination. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.5.1.3.1 discusses the intake and exhaust fans that are to provide the airflow for radiation and heat removal during the post-closure period. The discussion states that the air quantity exhausted from each emplacement drift will be approximately 40,000 cubic feet per minute (cfm), but does not indicate the total air quantity to be handled by each of the four intake and six exhaust shafts. Based on approximately 30 emplacement drifts per exhaust shaft, each exhaust shaft must be able to handle 1.2 million cfm. Although two fans are planned for each exhaust shaft (SAR Subsection 1.3.5.1.3.1 at 1.3.5-7), they should be completely redundant so that each fan must be capable of handling 1.2 million cfm. (SAR Figure 1.3.5-3 at 1.3.5-38 clearly shows a vane-axial type fan.) In the past 15 years, few, if any, fans of this size have been built and installed and many of the former manufacturers of these fans are no longer in business. Consequently, the 12 fans of this size that will be needed likely do not currently exist.

The possibility of ventilation fan failures does not appear to have been given adequate consideration. Blade failures associated with this type and size of fan are not unusual, and lead times for delivery and installation of replacement blades are on the order of months. Historical data would indicate that the frequency of a fan blade failure for such large fans is approximately one failure of a set of blades per fan per 10 years of operation.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.3.5.1.3.1 and similar subsections, which describe the intake and exhaust fans for the facility, fail to provide sufficient detail to determine whether the ventilation fans will fulfill the requirements that the LA places on them, and as a result, the LA assumptions relating to the isolation of the emplacement drifts during the pre-closure period are unfounded. Thus, SAR Subsection 1.3.5.1.3.1 and similar subsections do not comply with 10 C.F.R. § 63.112(e), which requires an analysis of the structures, systems and components to identify those that are important to safety. This analysis shall describe the controls that are relied on to limit or prevent potential event sequences or mitigate their consequences including the means to limit the concentration of radioactive material in air and the means to control the dispersal of radioactive contamination.

NEV-SAFETY-139 - DESCRIPTION OF REASONABLE EMERGENCIES

1. A statement of the contention itself

SAR Subsection 5.7 and similar subsections, which discuss plans for dealing with radiological emergencies prior to permanent closure, fail to include sufficient detail to determine whether these plans will fulfill all of the requirements that the LA places on them, and as a result, the LA assumptions related to the effectiveness of the engineered barrier system are unfounded.

2. A brief summary of the basis for the contention

The LA assumes that the waste packages and other engineered barriers are installed within specified tolerances and in conformance with other engineering requirements; however, the lack of information on the systems for dealing with radiological emergencies during the pre-closure period, which by definition imply a failure of one or more components of the engineered barrier system, means that there is no assurance that this can be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.21(c)(21) requires that the SAR contain a description of the Emergency Plan for responding to and recovering from radiological emergencies that may occur any time before permanent closure as required by 10 C.F.R. § 63.161. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.7 purports to address the requirements of 10 C.F.R. § 63.21(c)(21) and 10 C.F.R. § 63.161 including the criteria contained in 10 C.F.R. § 72.32(b), for responding to and recovering from radiological emergencies that may occur during operations at the repository. The general requirements in 10 C.F.R. § 63.21(c)(21) do appear to be met by discussion presented in SAR Subsection 5.7; however, the more specific criteria given in 10 C.F.R. § 72.32(b) are not met. Specifically, the types of radioactive material accidents are not identified, a classification system for classifying accidents as "alerts" or "site-wide conditions" is not provided, the means of detecting accidents are not given, and the methods for mitigating the consequences of each type of accident are not provided. Subsections within SAR Subsection 5.7 are provided that do purport to address these criteria; however, insufficient detail is provided to assure that the requisite planning is sufficient.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.7 and similar subsections, which discuss plans for dealing with radiological emergencies prior to permanent closure, because they fail to include sufficient detail to determine whether these plans will fulfill the requirements that the LA places on them, and as a result, the LA assumptions related to the effectiveness of the engineered barrier system are unfounded. Thus, SAR Subsection 5.7 and similar subsections do not comply with 10 C.F.R. § 63.21(c)(21), which requires that the SAR contain a description of the Emergency Plan for responding to and recovering from radiological emergencies that may occur any time before permanent closure as required by 10 C.F.R. § 63.161.

NEV-SAFETY-140 - ENGINEERED BARRIER SYSTEM DESIGN BASIS

1. A statement of the contention itself

SAR Subsection 1.3.4 and similar subsections, which describe the design of ground control system, ventilation system and components of the engineered barrier system, fail either to include sufficient detail to determine whether the component discussed will fulfill the requirements placed on it by the LA or to provide sufficient reference to supporting documents that provide the required detail.

2. A brief summary of the basis for the contention

The LA assumes that the ground control system, ventilation system and components of the engineered barrier system are sufficiently designed to provide reasonable assurance that they will perform their assigned functions in conformance with engineering and regulatory requirements; however, the lack of design information means that there is no assurance that the systems will function as assumed.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. In respect of the pre-closure safety analysis, 10 C.F.R.§ 63.112(e) (part of Subpart E) requires an analysis of the structures, systems and components to identify those that are important to safety. This analysis shall describe the controls that are relied on to limit or prevent potential event sequences or mitigate their consequences including the means to limit the concentration of radioactive material in air and the means to control the dispersal of radioactive contamination. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.5.1.3.1 discusses the intake and exhaust fans that are to provide the airflow for radiation and heat removal during the pre-closure period. The discussion states that the air quantity provided to each emplacement drift will be approximately 32,000 cfm (cubic feet per minute), but does not indicate the total air quantity to be handled by each of the four intake and six exhaust shafts. Indeed, there is no statement anywhere within SAR Subsection 1.3.5 concerning the total airflow and pressure capacity of each of the twelve exhaust fans. Subsection 6.2.1, Main Fans, of a supporting document entitled "Subsurface Construction and Emplacement Ventilation" (01/24/2008), LSN# DEN001573151 at 11, does not provide the operating parameters of the fans either, but does reference another supporting document entitled "Subsurface Ventilation Network Model for LA" (01/14/2008), LSN# DEN001572123. The subsidiary reference document DEN001572123, which is not referenced in the SAR, does provide the operating parameters for each of the fans as well as friction loss calculations for various conditions within the repository. However, as stated previously, there is no reference to this information in the SAR and it is not clear, therefore, whether the operating parameters given are considered applicable in the context of the LA. This illustrates a general problem in determining what design information has been used as a basis for safety related statements in the LA.

SAR Subsection 1.3.3.5.1.1 identifies the TEV as a crane-rail-based transport assembly that moves waste packages on emplacement pallets from surface facilities to the emplacement drifts. The TEV is described at SAR page 1.3.3-30 as "a first-of-a-kind application of existing technology." However, the description that it is an application of existing technology is misleading, as all that is said is that "most components of the TEV are based on commercially available equipment," which implies adaptation of commercially available items and leaves some items to be developed specifically for this application. Also, development of the design of the TEV is at a very early stage, as it is stated that "Codes and standards have been evaluated and design requirements and testing specifications are being developed." This means that not only is there, as yet, no engineering design for the TEV, but that some of the requirements to be achieved through that design have yet to be defined. This lack of design information has a critical impact on the evaluation of post-closure safety using the TSPA-LA, because the TEV has the primary function of transporting waste packages to the repository subsurface for emplacement (*see* SAR Subsection 1.3.3.5 at 1.3.3-27). Precise emplacement is required because, "Waste package emplacement geometry and thermal loading may affect the scale at which condensation caps form (over waste packages, over panels, or over the entire repository), and the extent to which 'shedding' will occur as water flows from the region above one drift to the region above another drift or into the rock between drifts." SAR Table 2.2-5 at 2.2-259. In the absence of a TEV design, or even a complete set of design requirements, and bearing in mind that this is a unique, first-of-a-kind vehicle required to operate remotely in a hot, spatially restricted, high radiation, underground environment, it is not possible to have any confidence that the precise emplacement geometry required on thermo-hydrological grounds can be achieved. Therefore, water flows in the vicinity of drifts, including seepages onto waste packages, may not be as assumed in the TSPA-LA, with potential implications for corrosion and radionuclide release and transport that would, in turn, affect assessed radiological impacts on the RMEI.

SAR Subsection 1.3.4.7 identifies the Drip Shield Gantry as a crane-rail-based transport assembly that moves drip shields from surface facilities to the emplacement drifts. The Drip Shield component of the EBS is described (SAR at 1.3.4-31) as "a unique component" for which "there are no established industry practices for its design." By extension, the Drip Shield Gantry used to transport the drip shields must necessarily also be unique; however, this fact is not explicitly stated in SAR Subsection 1.3.4.7. SAR Subsection 1.3.4.7.2 at 1.3.4-27 through 1.3.4-29 describes many of the systems and components on the Drip Shield gantry are being similar to those on the TEV. Consequently, one can assume that, as for the TEV, not only is there, as yet, no engineering design for the Drip Shield Gantry, but that some of the requirements to be achieved through that design have yet to be defined. This lack of design information has a critical impact on the evaluation of post-closure safety using the TSPA-LA, because the Drip Shield Gantry has the primary function of transporting and placing the drip shields, which are one of the components of the Engineered Barrier System (EBS). In the absence of a Drip Shield Gantry design, or even a complete set of design requirements, and bearing in mind that this is a unique, first-of-a-kind vehicle required to operate remotely in a hot, spatially restricted, high radiation, underground environment, it is not possible to have any confidence that the precise emplacement geometry required for the drip shields can be achieved. Therefore, water flows in the vicinity of drifts, including seepages onto drip shields, may not be as assumed in the TSPA-

LA, with potential implications for corrosion and radionuclide release and transport that would, in turn, compromise the EBS.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 1.3.4 and similar subsections, which describe the design of ground control system, ventilation system and components of the engineered barrier system, because they fail either to include sufficient detail to determine whether the component discussed will fulfill the requirements placed on it by the LA or to provide sufficient reference to supporting documents that provide the required detail. Thus, these subsections fail to comply with 10 C.F.R. § 63.112(e), which requires an analysis of the structures, systems and components to identify those that are important to safety. This analysis shall describe the controls that are relied on to limit or prevent potential event sequences or mitigate their consequences including the means to limit the concentration of radioactive material in air and the means to control the dispersal of radioactive contamination. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

NEV-SAFETY-141 - GROUND SUPPORT DESCRIPTIONS

1. A statement of the contention itself

Subsection 1.3.4.4, and similar and related sections of the SAR, lacks detailed descriptions of ground support items, such as "super Swellex-type rock bolts" and "Bernold-type perforated liners" and treats them as generic, which is inappropriate for a final repository design.

2. A brief summary of the basis for the contention

Descriptions of some ground support items, such as "super Swellex-type rock bolts" and "Bernold-type perforated liners" in Subsection 1.3.4.4 of the SAR, are generic and insufficient regarding installation, and in the case of the rock bolts, whether they are inflated with water pressure, how much pressure, and how much (if any) water will be left in the sealed or unsealed rock bolts is not known.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1)(ii) requires the SAR to describe the hydrology of the site and its effect on the safety and performance of the repository, Section 63.21(c)(3)(ii)

requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.114(a) (also part of Subpart E) requires data related to geology, hydrology and geochemistry to define parameters and conceptual models used in the performance assessment. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Design documents are unreferenced and rock bolts are referred to generically as "friction-type" in SAR Figure 1.3.4-4 at 1.3.4-71. Also lacking from the description of "super Swellex-type rock bolts" and from SAR Figure 1.3.4-4 is the diameter of the hole into which the bolts are to be installed. The "Bernold-type perforated liner" lacks details of the size, shape, and spacing of the perforations and what effect this may have on moisture removal from the wall rock during the ventilation phase of pre-closure operations.

Thus, the generic and non-detailed descriptions of ground support items, such as "Swellex-type" rock bolts or "Bernold-type" perforated liners in Subsection 1.3.4.4 of the SAR, are insufficient for a final design document that the SAR purports to be. There may even be additional so-called temporary rock bolts with smaller diameters (less than 2 inches, i.e., split sets) and shorter penetration distances into the drift wall rock (approximately 1 m) that are to be installed in a first pass and then, without removal, simply covered up by the Bernold-type liners in a second pass. *See* "Re: Estimate of committed initial ground support materials" (07/07/2004), LSN# DN2001754803. There is no mention of these temporary rock bolts in the SAR (*see, e.g.*, SAR Subsection 1.3.4.4), and they are not shown on SAR Figure 1.3.4-4.

With only this limited information available, it is not possible to evaluate the impacts of ground support items on the hydrological, thermal, and mechanical characteristics of the near field of the repository.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 1.3.4.4, and similar and related sections, lacks detailed descriptions of ground support items, such as "super Swellex-type rock bolts" and "Bernold-type perforated liners" and treats them as generic. With only this limited information available, it is not possible to evaluate the impacts of ground support items on the hydrological, thermal and mechanical characteristics of the near field of the repository. Thus, these subsections fail to comply with 10 C.F.R. § 63.21(c)(14), which requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation, 10 C.F.R. § 63.102(h), which requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository, 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures, and 10 C.F.R. § 63.115, which addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting.

NEV-SAFETY-142 - STANDARD TITANIUM GRADES CONSIDERED

1. A statement of the contention itself

In SAR Subsection 2.1.1.2 and similar subsections, DOE considered only standard ASTM specification titanium for the drip shields, which is an inadequate basis for design and results in significant differences in corrosion performance of the drip shield surface, structural members and welds, for which the LA provides inadequate information to demonstrate the performance DOE assumes for the titanium alloys selected for fabrication of the drip shields.

2. A brief summary of the basis for the contention

The drip shields are proposed to be fabricated of several different grades of titanium which have different strength and corrosion-resistance properties which when combined cannot be assumed to perform as represented in the LA.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure

performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. Finally, 10 C.F.R. § 63.114(f) requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Also, 10 C.F.R. § 63.114(g) requires provision of the technical basis for models used in the performance assessment such as comparisons made with outputs of detailed process-level models and/or empirical observations (*e.g.*, laboratory testing, field investigations, and natural analogs). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The LA and SAR Subsection 2.3.6 refer to early material corrosion tests conducted with Titanium (Ti) Grade 16, a "lean palladium" (0.06Pd) version of a palladium enhanced 50 ksi UTS unalloyed titanium. The Grade 16 test results are presented as an acceptable surrogate for Grade 7 results in several places in the SAR. Justification for substitution of the more expensive Grade 7 "standard palladium" (0.15Pd) is not provided, and could only be justified by uncertainty in the Grade 16 reference corrosion test results.

DOE failed to consider composition options other than the existing ASTM "standard" grades and has not left an option to take advantage of development of new and better materials. It would be a simple exercise to optimize the palladium content of the base and weld materials and develop a project specification (or even propose it to ASTM and AWS) for the materials. Recently introduced 16H and 7H Grades of titanium that are identical to Grades 16 and 7, but take advantage of 16% higher specified minimum tensile properties, might be considered as an alternate to Grade 7, but this is precluded by DOE's narrow approach.

DOE LA documents indicate that Grade 25 Titanium (Ti 6Al-4V-0.06Pd) was originally considered, but the choice was later modified to Grade 29 Titanium (Ti 6Al-4VELI-0.1Ru). This change may have been driven by realization that standard Ti 6Al-4V material (with higher oxygen and iron levels) was found to be more susceptible to stress corrosion cracking (SCC) than the low interstitial (ELI) grades. However, DOE does not clarify how the change to Ru was justified (there were significant speculative price pressures on Pd at the time these choices were made, and the Ru alloys were developed to address them, but subsequently similar pressures have acted on Ru, so a purely economic-based choice should have left the door open for either a Pd or Ru material, given how many years in the future this work was envisioned). DOE failed to consider a Ti 6Al-4VELI-0.06Pd or 0.015 Pd alloy, possibly because it was not listed in the ASTM Specifications. DOE failed to consider that it had the option to develop such a grade (even though it would just be a low interstitial version of the Grade 25 DOE considered initially, and would not have been at all difficult to develop) for a project with such large material requirements.

While the conventional wisdom is that Pd and Ru are interchangeable in terms of their effect on modifying the surface chemistry and thus on corrosion resistance of titanium (roughly doubling the Ru level to compensate for differences in how effective it is compared to Pd), there is not much data or experience in industry to show if using the two materials in combination carries all of the same benefits.

When the Ru grades were first introduced commercially in the late 1990's, there was a concern for availability of welding filler metal. To work around this problem, the industry proposed that ERTi-7 filler metal could be substituted for welding Grade 16 or Grade 26, and the resulting weld would provide comparable or better corrosion performance. The use of the Ru filler metal grades such as ERTi-26 was never suggested for welding Grade 7 or Grade 16 (Ti50A-0-.15Pd and Ti50A-0.05Pd). Consequently, there is no known industrial experience on which to base an assumption that this would work for short-term corrosion performance, let alone for more uncertain long-term requirements.

DOE failed to consider selecting a welding filler metal with a higher Pd (or Ru equivalent) content than the standard ERTi-7, so water diversion surface weld corrosion rates would be more comparable with the Gr. 7 base material.

Ti-Ru alloy microstructures are significantly different from Ti-Pd microstructures, in that the Ti-Ru alloys have a definite second metallurgical phase. This second phase could have a significant effect on the relative sensitivity of the two materials to hydrogen effects. This possibility does not appear to have been considered in the LA, even though concerns for SCC and hydrogen do appear.

DOE failed to consider if the design might have been safer and more reliable using either all Ru or all Pd enhanced titanium grades or alloys.

DOE failed to consider if the use of a ruthenium grade for the water diversion surface, perhaps with a higher ruthenium level than typical Grade 26 (more comparable to Grade 7 in corrosion resistance) might have reduced hydrogen concerns.

DOE failed to justify the use of higher strength Grade 29. DOE failed to consider using just a single all-Alpha grade like Grade 7 or 16 for the structural members. Grade 29 is more difficult to fabricate than Grade 7 and is less forgiving of fabrication errors. The use of the Alpha-Beta Grade 29 alloy welded to the all Alpha Grade 7 raises questions about sensitivity to long-term hydrogen diffusion and delayed cracking around welded joints. All Grade 7 (or Grade 16) construction would substantially eliminate this hydrogen concern.

DOE did not consider that the use of the single alloy would also reduce concerns for weld filler metal selection errors. The lower strength Grade 7 alloy is easier to fabricate and weld (more tolerant of imperfect cleaning and shielding practice, more readily formed to tighter bend radii) and would be more forgiving in terms of providing greater ductility in the event of a rock fall that caused shield collapse.

DOE did not consider that the use of Grade 7 for the structural members would reduce questions regarding stress relief of material of such different strength levels, and might even eliminate the concern for reduction of residual stresses to reduce risk of SCC (assuming that the DOE concern with stress relief is primarily related to SCC of Grade 29) that appears to be driving the requirement for stress relief in the first place. DOE did not assess how elimination of stress relieving would eliminate risks of hydrogen pick-up (for example, if a slightly reducing furnace atmosphere was inadvertently used), and of distortion due to uneven heating or cooling of the structure during stress relief.

DOE's reliance on immersion corrosion test results and failure to adequately consider localized corrosion is not appropriate given that the normal mode of failure of titanium is oxide film breakdown, usually manifested as local corrosion in the form of pitting, crevice corrosion, or under deposit corrosion. DOE's failure to even test all of the combinations of material proposed, in the welded condition, and with the heavily oxidized surface condition that will result from stress relieving add to the uncertainty surrounding this aspect of the project. DOE failed to test a realistic under-deposit (evaporated salts left from seepage water) corrosion mechanism exacerbated by the hot wall conditions and the insulating effect of the deposit itself that will exist on the drip shield, particularly in the earliest period following closure. Such a test has been shown by the State of Nevada (*see* "C22 Corrosion in Dripped Pore Water" (04/23/2008), LSN# NEV000005216 at 1-17) to cause corrosion in Alloy 22. Tests of Grade 7 or ERTi-7 welds, let alone of Grade 29 and ERTi-29 welds or ERTi-28 welds between Grade 7 and Grade 29) under these same conditions or at the even higher temperature possible in the repository in the near term after closure have the potential to fail by a similar corrosion mechanisms.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

DOE has assumed that the drip shields will function for hundreds of thousands of years based on corrosion testing of wrought and welded titanium (Grade 16 and Grade 7), as described in SAR Subsection 2.3.6 and similar subsections, but has not considered custom compositions to make corrosion performance of welds and structural components more uniform. Lower corrosion resistance of welds and structural components may lead to early failure of the drip shields. Thus, these subsections of the SAR do not comply with 10 C.F.R. § 63.114(f), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment, would be significantly changed by their omission. Nor do they comply with 10 C.F.R. § 63.114(g), which requires provision of the technical basis for models used in the performance assessment such as empirical observations (*e.g.*, laboratory testing).

NEV-SAFETY-143 - AVAILABLE DRIP SHIELD DESIGN INFORMATION

1. A statement of the contention itself

In the "Yucca Mountain Project Engineering Specification for Prototype Drip Shield & Drip Shield Fabrication Specification; 000-3SS-SSE0-00100-000-00Bb" (12/06/2006), LSN# DN2002362768, in SAR Figures 1.2.3-14 and 15, and 2.3.4-56, and throughout SAR Subsection 1.3.4.7 and similar subsections, DOE fails to provide necessary information to adequately understand and evaluate the drip shield design, fabrication, or installation.

2. A brief summary of the basis for the contention

SAR Subsection 1.3.4.7 and similar subsections and the Drip Shield Fabrication Specification (and the conceptual sketches therein) are inadequate to allow complete assessment of the drip shield design concept, and risk issues associated with fabrication, installation, and performance have not been considered adequately in the TSPA.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the

engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In SAR Subsection 1.3.4.7 and similar subsections DOE has failed to provide adequately detailed conceptual details of design of the drip shield that are critical to assessment of its capability to provide the functions for which it is designed and that are assumed in the LA. For example, the internal and external structural supports envisioned and how they would be attached to the water diversion surface (WDS) are not well defined, leading to questions of whether they would provide a continuous high-strength framework or are just separate sections welded to the Grade 7 WDS.

DOE suggests that the WDS might be fabricated from two side plates and a formed top, with a weld at the rigid corner between them. Such a construction would sacrifice significant deformation absorption capability of the structure, with little benefit in simplification or cost reduction of fabrication. It is does not seem that this reduction in deformation absorption capability has been taken into account in the post-closure safety assessment report.

DOE failed to consider alternatives to using high strength Grade 29 for the structural support with all the issues related to hydrogen, stress corrosion cracking (SCC), filler metal selection and use, *etc*. that Grade 29 introduces. DOE failed to consider a design that used larger cross sections of Grade 7 or Grade 16 as alternatives for Grade 29 structural components, an approach that would have addressed concerns with hydrogen cracking, filler metal mix-ups, and provided improved corrosion resistance, a clear demonstration that DOE did not consider all reasonable alternatives.

Interlocking Connector Issues

DOE does not make clear how the "interlocking" of the drip shields will be accomplished. "Analysis of Mechanisms for Early Waste Package/Drip Shield Failure, ANL-EBS-MD-000076 REV 00" (6/29/2007), LSN# DN2002451287, Subsection 6.2.2 at page 6-13 only describes the feature as follows:

> There will be two drip shield segments; a long one and a shorter one that is designed to overlap and attach two long sections together while assuring that the joint between them does not leak water while in service.

In the "Drip Shield and Waste Package Emplacement Pallet Design Report 000-00C-SSE0-00100-000-00B" (08/09/2007), LSN# DN2002459185, Section 6.1.1.2, the connection is described at page 13 as follows:

> All drip shields are uniformly sized so that one design can be used to enclose all waste package types. The drip shield segments are designed to accommodate an interlocking feature to prevent separation between the contiguous segments (Figure 2). This feature consists of an overlapping section with connector guides between the drip shield segments. The minimum lift height required to interlock the drip shield segments is at least 40 inches (1.016 m) (Reference 2.2.12) for clearance between the two drip shield segments.

Also under Satisfaction of Requirement 6.2.6.11 at page 24:

> **Requirement 6.2.6.11** The drip shield to drip shield interface shall not preclude the exchange of atmosphere between the volumes above and below the drip shields through that interface. (Derived from Reference 2.2.28, Table 1, Item 07-06).
>
> Satisfaction of Requirement 6.2.6.11: The drip shield to drip shield interface is simply overlapping contact with no seal that could preclude the movement of air (*See* Figure 2 and References 2.2.23, 2.2.25, and 2.2.26). Therefore Requirement 6.2.6.11 is satisfied.

DOE's description of "overlapping contact" is unclear in terms of how close a tolerance will be required between adjacent drip shields and connecting plates. DN2002459185, Section 6.1.1.2 at 13, describes a requirement for "minimum lift height required to interlock the drip shield segments is at least 40 inches (1.016 m) (Reference 2.2.12) for clearance between two drip shield segments" that further confuses how this is presumed to work. It could be a simple overhanging connector piece with large clearances to make emplacement easier, or a precisely machined interface with attendant demands on the placement system, or a complex plate arrangement that requires accurate lifting and sliding of a drip shield to put it in position, in which case, DOE does not address how it will meet a close alignment requirement without disturbing a drip shield already placed over a waste package.

Mention of final machining following stress relief (in DN2002459185, under Requirement 6.2.6.12, at 25) leads one to think there is consideration for precision machining of mating surfaces, something that would put inordinate requirements on the fabrication itself as well as on the emplacement system.

A full scale, or at least half-scale demonstration of this connection feature and function, even fabricated of low cost steel, done by remote operators, even under conditions not as severe as might be encountered in the drift environment after 75 years of degradation, is important to provide at least some assurance that this feature can be implemented. Pending such a demonstration, it is not appropriate to rely on any aspects of this feature for safety related purposes.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

In SAR Subsection 1.3.4.7 and similar subsections, DOE has failed to provide adequate information necessary to understand the design and fabrication of the drip shields. Therefore, the performance of the drip shields, with regard to waste isolation, cannot be adequately evaluated and their performance cannot predicted as part of the engineered barrier system. Thus, these subsections do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

NEV-SAFETY-144 - DRIP SHIELD FAILURE MECHANISMS

1. A statement of the contention itself

SAR Subsection 2.3.4.5.3.1 and similar subsections do not consider all of the applicable failure mechanisms for the drip shields or provide sufficient design information in order to evaluate all possible failure mechanisms.

2. A brief summary of the basis for the contention

SAR Subsection 2.3.4.5.3.1 and similar subsections identify a limited range of failure mechanisms based on design information that is insufficient even to fabricate a drip shield and is certainly inadequate to evaluate its performance in the conditions that would be present in the proposed repository.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and

the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE describes in SAR Subsection 2.3.4.5.3.1 only two mechanisms of mechanical failure of the drip shield: (a) collapse of the supporting leg structure; or (b) a general failure of the water diversion surface (WDS). How the drip shield is expected to fail, other than by general corrosion over thousands of years, or collapse where the water diversion surface integrity is supposedly maintained has not been addressed. Titanium and titanium alloys have limited ductility, and are not capable of sustaining large deformations without breaking. Such failures would be expected at weld joints, specifically those connecting the WDS to the structural members, and at hard points where the WDS is attached to a stiffer structural member, or at the top corner welds of the WDS. However, the LA does not provide sufficient detail to do anything more than guess as to how the joint details might perform. These failure mechanisms are not considered in the LA and could have a considerable impact on the assumed performance of the engineered barrier system.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

In SAR Subsection 2.3.4.5.3.1 and similar subsections, DOE has failed to consider all of the drip shield failure mechanisms that could affect performance of the engineered barrier system and the timing and dose to the RMEI. Thus, these subsections do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-145 - DRIP SHIELD SPECIFICATIONS

1. A statement of the contention itself

SAR Subsections 1.3.4.7.8 and 1.3.2, and Table 1.3.2-5, and similar subsections, list design codes and standards presumed applicable to the design and fabrication of the drip shield, but include specifications that are not appropriate or relevant and omit specifications necessary to the unique requirements to fabrication of drip shields from titanium such that they will meet the assumptions used in the TSPA for this "important to waste isolation" component of the engineered barrier system.

2. A brief summary of the basis for the contention

The proposed drip shields are supposedly to be fabricated from titanium to a high standard of quality and predicted long-term performance, but without adequate specifications and quality control procedures required to assure that fabrication to such standards is achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(3)(ii) requires the SAR to discuss the

design of the engineered barrier system and its relationship to the post-closure performance objectives, and Section 63.21(c)(14) requires the SAR to evaluate the natural features of the geologic setting and the design features of the engineered barrier systems important to waste isolation. 10 C.F.R. § 63.102(h) (part of Subpart E) requires the performance assessment to address how the natural barriers and the engineered barrier system work in combination to enhance the resiliency of the geologic repository. 10 C.F.R. § 63.113 (also part of Subpart E) requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures. Finally, 10 C.F.R. § 63.115 (also part of Subpart E) addresses barriers important to waste isolation recognizing both the engineered barrier system and the natural features of the geologic setting. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceedings.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The specifications referenced by DOE for controlling drip shield design and fabrication are inadequate and unclear. SAR Table 1.3.2-5, and other places in the SAR, reference non-applicable nuclear codes and provide inadequate process or quality guidelines which obfuscate the desired fabrication and quality assurance provisions for drip shield manufacture.

Instead of referring to non-applicable nuclear specifications in the hope that it will somehow convince readers that everything will be excellent, a project-specific specification covering important issues related to material and fabrication is needed as part of the LA. Including fairly detailed fabrication and welding requirements is standard industry practice at this stage of a project. While obviously such a specification would be preliminary, it could certainly address important sourcing, ingot and mill product material, design, welding, fabrication, and quality assurance issues.

DOE appears to be relying on the ASTM plate specification, which may be adequate for some of the material requirements, but DOE fails to state if it will require added sponge and scrap controls, melt controls, supplemental bend testing or some other means to verify surface condition (free of an embrittling oxygen-rich surface layer) on the hot rolled surfaces, and does not address other mill product quality features that the LA appears to assume will be achieved.

DOE has failed to specify the requirements for qualifying welding procedures and welders, other than by indirect reference to the ASME Code. It would appear that DOE is relying on ASME Section IX, but for the high quality levels DOE says will exist, more rigorous requirements will need to be imposed, *e.g.*, additional testing, and something like a 6G pipe weld for welder qualification.

The engineering of the drip shield should include a specific plan for weld quality controls specific to each type of weld in the system. This is much easier if a detailed conceptual design is available. At this stage, it is impossible to determine what sort of weld design is anticipated for structural welds, for example.

The water diversion surface (WDS) welds are specified to be full penetration welds but verification steps might include visual fit-up inspection, root pass inspection, ultrasonic testing, and X-Ray (not iridium) radiography. Ultrasonic testing could be considered in lieu of or as a supplement to radiography. On the other hand, structural welds are likely to be fillet welds, but DOE needs to state if they are to be intermittent welds or continuous seal welds. The specification for these welds could include visual fit-up, root pass inspection, final visual, and liquid penetrant testing, with no radiography or ultrasonic testing.

A simple definition of critical dimensional inspection requirements is clearly necessary, although a reasonable design for this function should not need to include any critical hard dimensions with overly precise tolerances. A clear definition of the types of welds expected for various functions is needed.

In respect of limitations of the cited codes and standards, the ASME Code, for example, is designed primarily for pressure-retaining vessels and includes little, outside of a welding qualification standard (Section IX) and possibly some welding design details, that is directly applicable to the shield detail design or fabrication. Loads, for example, that the structure must be designed to resist are not defined, and are clearly beyond the scope of ASME and the usual scope and capability of a fabricator. The LA should be specific as to just what sections of the ASME Code it is relying on. References to nuclear specifications that have little to do with a structure like the drip shield appear as a smokescreen to disguise a lack of understanding of the specific requirements for design and fabrication for the drip shield.

The "Specification Cover Sheet & Yucca Mountain Project Engineering Specification for Prototype Drip Shield & Drip Shield Fabrication Specification; 000-3SS-SSE0-00100-000-00Bb" (12/06/2006), LSN# DN2002362768 and the conceptual drawings ("Drip Shield Sub-Assembly 000-M00-SSE0-00501-000" (04/23/2007), LSN# DN2002410395; "Drip Shield Sub-Assembly 000-M00-SSE0-00502-000" (04/23/2007), LSN# DN2002377531; "Interlocking Drip Shield Configuration 000-M00-SSE0-00101-000" (04/05/2007), LSN# DN2002368873; "Interlocking Drip Shield Configuration 000-M00-SSE0-00102-000" (04/05/2007), LSN# DN2002373607; "Interlocking Drip Shield Configuration 000-M00-SSE0-00103-000" (04/05/2007), LSN# DN2002410317; and SAR Fig. 1.3.4-14 at 1.3.4-89, Fig. 1.3.4-15 at 1.3.4-91 and Fig. 2.3.4-56 at 2.3.4-313) fail to provide adequate guidelines for what is expected from the fabricator in terms of design, fabrication, inspection, and acceptance requirements, nor does it address adequately the issues related specifically to titanium welding (weld contamination due to oxygen).

DN2002362768 indicates that the final acceptance of the model is to be based on its weight. There is no mention of dimensional inspection, to name the most obvious. Thus, DOE fails to define a suitable basis for acceptance of the drip shield before it leaves the fabrication shop.

With no design details to evaluate, it is difficult to assess how realistic it is to think the WDS will continue to function after a rockfall collapses a drip shield. It is not clear how the drip shield will actually fail, particularly given the uncertainty in how it might be loaded by an uncontrolled rockfall. It is also possible that the weld details used to attach the high strength structural members to the lower strength WDS will fail by tearing through the wall of the WDS, opening passages for seepage water. Adequate scale model tests, or at minimum finite element analysis (FEA) simulations of the drip shield design under extreme loading conditions anticipated during a rock fall or seismic event are needed to demonstrate how it might fail.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 1.3.4.7.8 and related subsections provide insufficient and irrelevant specifications on design and fabrication of drip shields, making predictions of performance/failure mechanisms of the drip shields as represented in the TSPA unreliable. Drip shield failure impacts the timing and dose to the RMEI. Thus, SAR Subsection 1.3.4.7.8 and related subsections do not comply with 10 C.F.R. § 63.113, which requires the geologic repository to be designed with proper consideration to the engineered barrier system working in combination with the natural barrier to limit radiological exposures.

NEV-SAFETY-146 - RELIANCE ON PRELIMINARY OR CONCEPTUAL DESIGN INFORMATION

1. A statement of the contention itself

Legal Issue: The LA cannot be granted because it relies on preliminary or conceptual design information for both pre-closure and post-closure aspects.

2. A brief summary of the basis for the contention

10 C.F.R. Part 63, especially Sections 63.21, 63.24, 63.31, 63.101, 63.102, and 63.111 through 115, considered with its history and contemporaneous NRC and DOE interpretations, require an essentially one-step licensing process in which the final design must be submitted and approved before a construction authorization may be issued. Preliminary and conceptual design information of the type found in the LA is not final design information.

3. A demonstration that the contention is within the scope of the hearing

This issue challenges compliance with applicable NRC regulations which, under 10 C.F.R. § 63.31(a)(3), must be satisfied before a construction authorization may be issued. Further, it is within the scope of the hearing as provided in Section II, paragraph 1 of the notice of hearing. Further still, this same issue was raised in Nevada's June 4, 2008 petition to reject DOE's tendered application, and in response, the Commission ruled in CLI-08-20 that "[t]he matters raised in Nevada's . . . filings would be appropriately raised for consideration in response to [the] notice of hearing" and that dismissal of Nevada's petition was "without prejudice to the petitioners' right to pursue identical claims, but in the form of proposed adjudicatory contentions. . . ." CLI-08-20 at 4, 5.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

This issue challenges compliance with applicable NRC regulations which, under 10 C.F.R. § 63.31(a)(3), must be satisfied before a construction authorization may be issued. It therefore presents a material issue.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

This contention raises a purely legal question, and supporting facts and opinions are not necessary beyond those discussed below.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the legal sufficiency of DOE's description of its pre- and post-closure designs in all pages of SAR Subsections 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.5, 1.3.6, 1.4.1, 1.4.2, 1.4.3, 1.4.4, 1.5.2, 1.9, 2.1.2.2, and related sections. Specific examples of deficiencies are offered in Nevada's July 21, 2008 Supplement to its June 4, 2008 Petition Asking the NRC to Reject DOE's Yucca Mountain License Application as Unauthorized and Substantially Incomplete. In particular, there is no final TAD design. Also, DOE's own application planning documents call for the application to be based on preliminary design information. *See, e.g.*, "Desk Top Instructions for Preparing Preliminary Design Drawings for License Application" (01/14/2004), LSN# DN2001625181, Section 3.1 at 3 ("Engineering drawings prepared for LA will be preliminary design drawings").

Supporting reasons are that 10 C.F.R. Part 63, especially Sections 63.21, 63.24, 63.31, 63.101, 63.102, and 63.111 through 115, considered with its history and contemporaneous NRC and DOE interpretations, requires an essentially one-step licensing process where the final design must be submitted and approved before a construction authorization may be issued.

Preliminary and conceptual design information of the type found in the application is not final design information.

(s) Human Reliability Analysis

NEV-SAFETY-147 - EVALUATION OF DATA USED IN DRIP SHIELD FAILURE PROBABILITY

1. A statement of the contention itself

SAR Subsection 2.3.6.8.4.3.2.4 and similar subsections, which give an estimate for the occurrence that a drip shield is improperly installed in the repository, fail to provide an appropriate technical basis for parameter ranges and probability distributions used in the performance assessment due to the use of inappropriate data.

2. A brief summary of the basis of the contention

The estimate of the probability that a drip shield is improperly installed in the repository, which makes use of data on human reliability as described in SAR Subsection 2.3.6.8.4.2 and Table 2.3.6-22, relies on data that were developed for nuclear power plants and these data are not applicable to the specific conditions of subsurface operations at Yucca Mountain.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance

assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.6.8.4.3.2.4 assesses the frequency for occurrence that a drip shield is improperly installed in the repository leaving a gap between adjacent drip shields. This frequency directly affects the safety assessment, as it results in water penetration and the early failure of an underlying waste package. The probabilities used in the analysis are based upon whether or not the operator will notice and respond to the error, and whether a checker will recognize the error and respond. Thus, all these probabilities are estimates of human reliability. The data used are set out SAR Table 2.3.6-22 and two DOE reference documents: "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications Final Report," NUREG/CR-1278 (1983), LSN# DN2002064865, all; and "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities (U)" (02/28/1994), LSN# DEN001584210, all.

However, neither of these reference documents is relevant to the specific conditions that will apply in the subsurface at Yucca Mountain. Furthermore, the human error probabilities (HEPs) used do not relate closely to the activities involved. For example, inspection of the connection between two drip shields by video camera observation is described as, "Error of commission of check reading analog meter with difficult to see limit marks, such as scribe lines." (DN2002451287, Table 4-1 at 4-2.) Also, no attempt has been made to adapt the data to the specific conditions at Yucca Mountain. Specifically, "Analysis of Mechanisms for Early Waste Package/Drip Shield Failure" (6/29/2007), LSN# DN2002451287, Section 4 at 4-2 states:

> The fact that the HEP values given in Table 4-1 correspond to nominal probabilities should be emphasized. No performance-shaping factors are used for this evaluation. In general, performance-shaping factors are utilized to alter the nominal HEP in order to account for the effects of factors such as equipment design, operator skills, and psychological and physiological stresses. Because the procedures and equipment that will be put into service to perform the fabrication and handling of the waste package outer corrosion barrier and the drip shield have not yet been precisely identified, use of performance shaping factors is inappropriate.

However, it would be more appropriate to state that because the procedures and equipment that will be put into service have not been specified, no reliance can be placed on generic factors derived for other purposes that have not been demonstrated to be relevant to the proposed application. Furthermore, as these generic factors are used multiplicatively, the errors arising from their use in this application will be compounded. Thus, the overall error in the assessed frequency of improper drip shield installation could be several orders of magnitude.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.6.8.4.3.2.4 and similar subsections present an estimate for the occurrence that a drip shield is improperly installed in the repository that is based on generic data derived for purposes remote from those of relevance to the procedures and equipment that will put into service in the sub-surface at Yucca Mountain. Furthermore, because those procedures and equipment have not been specified, the degree to which these generic factors are in error cannot be reliably quantified. Nevertheless, because these generic factors are used multiplicatively, the errors arising from their use in this application will be compounded. Thus, the overall error in the assessed frequency of improper drip shield installation could be several orders of magnitude. Thus, DOE has failed to comply with the requirements of 10 C.F.R. § 63.114(b) because it does not provide an appropriate technical basis for parameter ranges and probability distributions used in the performance assessment. Furthermore, this failure to comply directly impacts estimates of the numbers of early waste package failures and hence the overall results from the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-148 - EVALUATION OF COMPUTATIONAL PROCEDURE USED IN DRIP SHIELD FAILURE PROBABILITY

1. A statement of the contention itself

SAR Subsection 2.3.6.8.4.3.2.4 and similar subsections, which give an estimate for the occurrence that a drip shield is improperly installed in the repository, fail to provide an appropriate technical basis for parameter ranges and probability distributions used in the performance assessment due to manipulation of the underlying human reliability data by use of an inappropriate computational procedure.

2. A brief summary of the basis of the contention

The estimate of the probability that a drip shield is improperly installed in the repository, which makes use of data on human reliability as described in SAR Subsection 2.3.6.8.4.2 and Table 2.3.6-22, inappropriately treats the various human reliability factors as independent and does not consider all potential pathways to failure.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.6.8.4.3.2.4 assesses the frequency for occurrence that a drip shield is improperly installed in the repository leaving a gap between adjacent drip shields. This frequency directly affects the safety assessment, as it results in water penetration and the early failure of an underlying waste package. The probabilities used in the analysis are based upon whether or not the operator will notice and respond to the error, and whether a checker will recognize the error and respond. Thus, all these probabilities are estimates of human reliability.

The details of the analysis are set out in DOE reference document "Analysis of Mechanisms for Early Waste Package/Drip Shield Failure" (06/29/2007), LSN# DN2002451287, Section 6.4.4, at 6-61 to 6-63. The argument is that four failures have to occur in order to result in an emplacement error: (a) the operator fails to interlock the drip shield properly; (b) the failure is not detected by a remote camera inspection; (c) the operator fails to respond to a process malfunction annunciator; and (d) the checker fails to detect that the operator has not responded to a process function annunciator. These four probabilities are treated as independent events. Based on this analysis, the overall frequency for occurrence that a drip shield is improperly installed is estimated as 4.36×10^{-9}.

Although the mathematics of this analysis is straightforward, the underlying principles are suspect and the result is of little value. Common sense would question whether a process that relies entirely upon human skill and judgment (note that all four steps (a) through (d) require either human actions or human responses) can achieve a failure rate of below one in one hundred million.

Some key factors that are likely to make the approach erroneous are listed below:

1) It assumes that the process malfunction annunciator is operating. If it is not operating then the operator cannot respond to it and the checker cannot recognize that failure to respond.

2) It assumes that remote camera and annunciator operations are maintained throughout the repository filling period. However, with a routine connection operation, there may be a tendency to switch off or ignore such QC measures, or to continue operations when one of the systems is out of operation.

3) On a related point, it assumes that remote camera inspection and annunciator give perfect information; if the camera provides ambiguous information then it may cease to be relied upon. Similarly, if the annunciator generates a significant rate of warnings when the interlocks between drip shields prove to be satisfactory, it may be ignored. Indeed, the very fact that both camera inspection and malfunction annunciator are provided may mean that one of these two sources of information is ignored (*e.g.*, there is no perceived need to look at the camera images because the annunciator will provide an alert as to there being a failure of emplacement).

More generally, where acts of human volition are involved, it is widely recognized that accidents or failures of performance tend to occur when rules are violated. *See* Breakwell, G.M. (2007), "The Psychology of Risk" (Cambridge University Press, Cambridge, UK) at 173-195, and in particular, conclusions at 194. In the case of drip shield emplacement, there will be little immediate evidence of a failure in emplacement (except that available to the operator and checker), nor is there necessarily any deleterious consequence for the operator or checker. Therefore, a degree of sloppiness is likely to enter into this repetitious procedure (*e.g.*, emplacements occur, in violation of rules, when the checker is not present, or camera images are not inspected by the operator, who relies on the annunciator for information as to whether there is a problem).

Finally, it is noted that it is not clear that the system fails to safety. If the process malfunction annunciator does not provide a signal, this could either be because the emplacement is satisfactory or because the malfunction annunciator is not operating.

Overall, because the procedures and equipment that will be put into service to ensure accurate drip shield emplacement have not been specified, and because various key factors are neglected in the analysis, no reliance can be placed on the overall frequency derived by DOE for the occurrence that a drip shield is improperly installed. Furthermore, by considering the largest possible number of events and treating them as independent, DOE has systematically underestimated this frequency.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

SAR Subsection 2.3.6.8.4.3.2.4 and similar subsections present an estimate for the frequency that a drip shield is improperly installed in the repository that is based on an inappropriate treatment of the various human reliability factors as independent and that does not consider all potential pathways to failure. This means that DOE has systematically underestimated this frequency. Thus, DOE has failed to comply with the requirements of 10 C.F.R. § 63.114(b) because it does not provide an appropriate technical basis for parameter ranges and probability distributions relating to improper installation of drip shields as used in the performance assessment. Furthermore, this failure to comply directly impacts estimates of the numbers of early waste package failures and hence the overall results from the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-149 - DEVIATIONS IN DESIGN AND WASTE EMPLACEMENT

1. A statement of the contention itself

Legal issue: In SAR Subsection 2.2.1.2 at 2.2-17, DOE excludes deviations from repository design or errors in HLW emplacement from events considered in the TSPA (FEP 1.1.03.01.0A) on purely legal grounds that are unexplained and erroneous.

2. A brief summary of the basis for the contention

The validity of the TSPA depends in important part on the proper identification of features, events and processes (FEPs). In SAR Subsection 2.2.1.2 at 2.2-17, DOE excludes deviations from repository design or errors in HLW emplacement from events considered in the TSPA (FEP 1.1.03.01.0A) on purely legal grounds that are unexplained and violate 10 C.F.R. §§ 63.114(d), 63.114(e), 63.114(f) and 63.342.

3. A demonstration that the contention is within the scope of the hearing

This contention questions whether DOE complies with 10 C.F.R. § 63.114(d), (e), and (f) and 10 C.F.R. § 63.342, which specify how FEPS are to be evaluated and either included or excluded from the TSPA, and it within the scope of the proceeding under section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This issue must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. § 63.31(a)(2), that there is reasonable assurance of safety, and to find, as required by 10 C.F.R. § 63.31(a)(3)(ii), that the site and design comply with Subpart E of 10 C.F.R. Part 63, which includes 10 C.F.R. § 63.114. The issue is therefore material.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Under 10 C.F.R. § 63.114, the validity of the TSPA depends in important part on the proper identification of FEPS. In SAR Subsection 2.2.1.2 at 2.2-17, DOE excludes deviations from repository design or errors in HLW emplacement from events considered in the TSPA (FEP 1.1.03.01.0A) on purely legal grounds. *See* "Features, Events and Processes for the Total System Performance Assessment: Analyses" (03/06/2008), LSN# DEN001584824 at 6-39 and 6-40, where it is explained that FEP 1.1.03.01.0A, which includes "deviations from the design and/or errors in waste emplacement" is excluded from the TSPA "on the basis of regulation," notwithstanding that these "would impact repository performance." No regulation is cited for this proposition, and it appears from the discussion that this FEP is excluded because DOE believes it must be assumed that the repository will be constructed and operated exactly as proposed in the LA and that DOE's QA program will be implemented with such perfection that no deviations or errors significantly affecting repository performance will occur. This proposition is belied by decades of nuclear experience, finds no support in any NRC regulation, and is contrary to 10 C.F.R. §§ 63.114(d), (e) and (f).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.2.1.2 at 2.2-17, and the supporting reference LSN# DEN001584824, which excludes deviations from repository design or errors in HLW emplacement from events considered in the TSPA (FEP 1.1.03.01.0A) on purely legal grounds that are unexplained and violate 10 C.F.R. §§ 63.114(d), (e), and (f) and 10 C.F.R. § 63.342. The reasons are given above.

(t) Igneous and Volcanic Effects

NEV-SAFETY-150 - BASALTIC MAGMA MELTING DEPTH

1. A statement of the contention itself

SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7×10^{-8} events/year, underestimates that probability, likely by two or more orders of magnitude, because it is assumed incorrectly that melting to produce basaltic magma will be in the shallow lithospheric mantle and not in the deeper asthenosphere.

2. A brief summary of the basis for the contention

DOE's assumption that the source of the basaltic magma is in the shallow lithosphere infers a dwindling supply of new basalt and little chance of future events. DOE does not account for published data and interpretations that indicate that melting to produce basalt is in the asthenosphere and not in the lithosphere. Melting of asthenosphere implies a more active igneous future for Yucca Mountain and a higher probability of igneous activity disrupting repository drifts.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. §

63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The SAR discusses the assumption that basaltic magmas were generated in the shallow lithospheric mantle mainly in Subsections 2.2.2.2.3.1 and 2.3.11.2.2. In SAR Subsection 2.2.2.2.3.1 at 2.2-97, and repeated in Subsection 2.3.11.2.2.5 at 2.3.11-23, it is stated that,

> The PVHA experts generally view volcanism in the Yucca Mountain region as a regional-scale phenomenon resulting from melting processes in the upper lithospheric mantle. . . .
>
> Analyses of magmatic processes in the Yucca Mountain region generally indicate that the magnitude of mantle melting has significantly decreased since the middle Miocene. The analyses also suggest that melts in the past few million years were generated within relatively cool ancient lithospheric mantle (compared to asthenospheric mantle), which is a factor that may contribute to the relatively small and decreasing volume of basaltic melt erupted in the Yucca Mountain region since the Miocene period (BSC 2004k, Section 6.3.3).

These statements are contrary to published research that clearly points out that melting of lithospheric mantle to produce basalt late in an extensional event, as DOE assumes, is difficult if not impossible. In several papers it was demonstrated that lithospheric mantle does not melt to produce basalt about Yucca Mountain. *See* "Episodic Volcanism and Hot Mantle: Implications for Volcanic Hazard Studies at the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada" (04/01/2002), LSN# NEV000002718 at 4-10; Smith, E.I. and Keenan, D.L. (2005), "Yucca Mountain Could Face Greater Volcanic Threat," EOS, TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION, Vol. 86, No. 35 at 317; and Smith, E.I., Conrad, C.P., Plank, T., Tibbetts, A., Keenan, D. (2008), "Testing Models for Basaltic Volcanism: Implications for Yucca Mountain, Nevada," AMERICAN NUCLEAR SOCIETY, PROCEEDINGS OF THE 12TH INTERNATIONAL HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT CONFERENCE at 157-164. Peridotite of the mantle lithosphere is too cold to melt. The only components that could melt are those with a lower solidus temperature than dry peridotite. These components were probably totally melted during previous events that produced the voluminous rhyolite ash-flow tuffs that now form Yucca Mountain.

Calculations of melting depths indicate that basalts at Yucca Mountain were produced by melting at depths of 115-133 km within the asthenospheric mantle. *See* "A Mantle Melting Profile Across the Basin and Range, SW USA" (01/22/2002), LSN# NEV000004173 at ECV 5-1 to ECV 5-21; NEV000002718 at 4-10; Smith, *et al.* (2008) at 157-164; and "Yucca Mountain Project Terry Plank Lamont-Doherty Earth Observatory Report on Activities from January 26, 2008 - February 26, 2008" (02/26/2008), LSN# NEV000005026 at 1-4. These calculations were done assuming a dry mantle, but even if water contents of 1-4.5 wt. % are considered melting is still deep in the asthenosphere. *See* NEV000005026 at 1-4; and Smith, *et al.* (2008) at 157-164.

Depth of melting calculations used the Fe-Na (*see* NEV000004173 at ECV 5-1 through ECV 5-21) and Silica (NEV000005026 at 1-4) geobarometers and were calibrated using basalt samples from the Big Pine Volcanic Field in eastern California. In the Big Pine example, both geobarometers placed melting in a zone of low-velocity (high temperature) asthenosphere at depths of 50 to 75 km. *See* NEV000005026 at 1-4. These calculations place high confidence in melting depths calculated using both the Fe-Na and Silicon barometers and strongly indicate that melting to produce basaltic magma is in the deep asthenosphere and not in the lithospheric mantle.

Prior to ten million years ago, shallow melting did occur in the Great Basin area, including in the Crater Flat Volcanic Field immediately adjacent to Yucca Mountain. Harry, D.L., Sawyer, D.S., and Leeman, W.P. (1993), "The Mechanics of Continental Extension in Western North America: Implications for the Magmatic and Structural Evolution of the Great Basin," EARTH AND PLANETARY SCIENCE LETTERS, Vol. 117 at 59-71, and Harry, D.L. and Leeman, W.P. (1995), "Partial Melting of Melt Metasomatized Subcontinental Mantle and the Magma Source Potential of the Lower Lithosphere," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 100 at 10255-10269, examined the effects of extension in the Great Basin in relation to melting of lithospheric mantle (shallow melting). They determined that certain components commonly found in the lithospheric mantle (mafic veins or water rich minerals) could be melted during the initial phases of extension. This would explain the widespread silica-rich volcanism during Oligocene time (33.7-23.8 million years ago). These studies also determined that the early melting events exhausted the lower melting temperature components in the lithospheric mantle. Consequently any volcanism after about 10 million years ago could not be from this source and must be from asthenospheric (deep) melting. Gallagher, K., and Hawkesworth, C.J. (1992), "Dehydration Melting and the Generation of Continental Flood Basalts," NATURE, Vol. 358 at 57-59, and Hawkesworth, C., Turner, S., Gallagher, K., Bradshaw, T., and Rogers, N. (1995), "Calc-Alkaline Magmatism, Lithospheric Thinning, and Extension in the Basin and Range," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 100 at 10271-10286, did a regional study of the Great Basin to determine the effects of the presence of water on subsurface melting. Their study concluded that lithospheric mantle will only melt with the presence of water (0.5 wt. %) and that lithospheric mantle will melt before asthenospheric mantle. They also concluded that the early voluminous volcanic activity likely depleted the water component that made lithospheric mantle melting possible. In addition, the large scale extension throughout the region caused thinning of the lithospheric mantle. This allowed upwelling of the asthenospheric mantle. The resulting decrease in pressure in the asthenosphere created conditions favorable to melting of this material. The depletion of water and resulting thinning of the lithosphere due to extension led the authors to the conclusion that little if any lithospheric mantle melting could have occurred more recent than 10 million years ago. Deep melting models are a more accurate way to explain the volcanism that occurred during the last 10 million years.

DOE uses an isotopic data set that shows that basalt near Crater Flat has higher Sr and lower Nd isotopic signatures than expected for asthenospheric sources. They use this data to support the shallow melting model. This isotopic data does not establish shallow melting because it is not inconsistent with deep melting. Lee, C.T., Yin, Q., Rudnick, R.L., Chesley, H.T., and Jacobsen, S.B. (2000), "Osmium Isotopic Evidence for Mesozoic Removal of Lithospheric Mantle Beneath the Sierra Nevada, California," SCIENCE, Vol. 289 at 1912-1916, suggested that basalts with the isotopic signatures found in the Crater Flat volcanic field could be related to contamination either by lithospheric mantle or by subducted crustal material. A later study (*see* Lee, C.T., Yin, Q., Rudnick, R.L., and Jacobson, S.B. (2001), "Preservation of Ancient and Fertile Lithospheric Mantle Beneath the Western United States," NATURE, Vol. 111 at 69-73) determined that Archean (>2.7 billion years old) crust may be present beneath the southern Great Basin area. Melting of Archean crust or contamination from it could account for the isotopic signatures.

In recent years there have been numerous studies based on a variety of data**,** all of which point to the presence of deep melting in the Yucca Mountain area and throughout most of the central Great Basin (reported in Wang, *et al.* (2002) at 10 ECV 5-1 through ECV 5-21, and Smith, *et al.* (2008) at 157-164). Indeed, DOE originally suggested melting of the asthenosphere to produce basalt. Perry and Crowe (1992), "Geochemical Evidence for Waning Magmatism and Polycyclic Volcanism at Crater Flat, Nevada," LSN# DN2001597248 at 1-10, noticed steep rare earth element patterns, which indicate deep melting. Furthermore, several geophysical studies (*see* Van der Lee, S. and Nolet, G. (1997), "Upper Mantle S Velocity Structure of North America," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 102 at 22815-22838; Savage, M.K., Lowry, A.R., Ribe, N.M., and Smith, R.B. (2000), "Dynamic Elevation of the Cordillera, Western United States," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 105 at 23371-23390; and Sheehan, A.F. (2000), "Seismic Anisotrophy and Mantle Flow from the Great Basin to the Great Plains, Western United States," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 105S at 13725-13734) all support hotter than normal mantle at depth in the central Nevada region and thus deep melting.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 2.2.2.2.3.1 and 2.3.11.2.2 and related sections, which state a major DOE assumption used to derive its probability estimate for igneous events, namely that melting to produce basalt near Yucca Mountain will occur in the shallow lithospheric mantle. If DOE were to make the correct assumption, SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7 x 10^{-8} events/year, would underestimate that probability, likely by two or more orders of magnitude.

The supporting reasons are given in Section 5 above and may be summarized as follows: DOE's assumption that the source of the basaltic magma is in the shallow lithosphere infers a dwindling supply of new basalt and little chance of future events. DOE does not account for published data and interpretations that indicate that melting to produce basalt is in the asthenosphere and not in the lithosphere. Melting of asthenosphere implies a more active igneous future for Yucca Mountain and a higher probability of igneous activity disrupting repository drifts.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to

each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-151 - TIME SPAN OF BASALTIC VOLCANISM

1. A statement of the contention itself

SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7×10^{-8} events/year, underestimates that probability, likely by two or more orders of magnitude, because DOE ignored the entire 11 million year span of basaltic volcanism near Yucca Mountain.

2. A brief summary of the basis for the contention

Despite the 11 million year long record of basaltic volcanism near Yucca Mountain, DOE uses the past 5 million years of the record to conclude both that volcanism near Yucca Mountain is decreasing in volume and number of events and that future eruptions are very unlikely. These observations do not consider the entire history of volcanism as recorded in surface outcrops and core from borings about Yucca Mountain that define two super-episodes of volcanism. Rather than a single slowly dying igneous system, volcanism near Yucca Mountain occurred in two periods over the last 11 million years, each lasting 3 to 4 million years. Both super-episodes show chemical signs of a waning volcanic system toward the end of their history. The implication is that volcanism near Yucca Mountain does not record a single waning system but represents igneous activity that periodically starts and stops. Two periods of volcanic activity have already occurred at Yucca Mountain. Consideration of the complete record would support the proposition that the eruption at Lathrop Wells at 78,000 years ago represents the beginning of a third super-episode.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.11.2.1.1 at 2.3.11-16, states that:

> The decreased eruptive volume through time, together with geochemical evidence (Perry, Crowe, *et al.*, 1998, p. 4-8) indicates that the intensity of mantle-melting processes beneath the Yucca Mountain region has waned over the past 5 million years (Perry and Crowe 1992, p. 2359; Perry, Crowe, *et al.*, 1998, p. 4-1). Considered in terms of total eruption volume, recurrence intervals, and duration of volcanism during the past 5 million years, the Crater Flat volcanic field,

> adjacent on the west to Yucca Mountain, is one of the least active basaltic volcanic fields in the western United States (BSC 2004a, Section 6.1.1.1).

Although volcanism over the past 11 million years is mentioned in SAR Subsection 2.3.11.2.1.1 at 2.3.11-16 ("Small-volume basaltic volcanism has continued into the Quaternary as part of the general decline in eruption volume over the past 11 million years in the Yucca Mountain region (Perry, Crowe, *et al.*, 1998, Chapter 2)"), emphasis is placed on activity over the past 5 million years ("Post-Miocene volcanism (younger than 5 million years) has occurred in six episodes, at approximately 4.6 (Thirsty Mountain), 3.8 (Southeast Crater Flat), 2.9 (Buckboard Mesa), 1.1 (Crater Flat), 0.35 (Hidden Cone and Little Black Peak), and 0.08 (Lathrop Wells) million years ago (Table 2.3.11-2). The recurrence interval between episodes is thus quite long, ranging between about 300,000 to 1.8 million years."). The study of the entire 11 million year old record tells a different story.

Yucca Mountain core provides a unique opportunity to view the volcanic history of the Yucca Mountain area back to 11 million years ago. Unlike previous work that limits analysis to post-5 million-year basalts (*see* Valentine, G.A. and Perry, F.V. (2007), "Tectonically Controlled, Time-Predictable Basaltic Volcanism from a Lithospheric Source" (02/07/2007), LSN# DN2002382703 at 201-216), the core provides a record from the beginning of basalt volcanism 11 million years ago. Rather than a pattern of decreasing volume and waning activity, the record from the core combined with data from surface exposures reveals two episodes of activity separated by a several million-year period of relative quiet. Within each episode, volcanism occurred periodically with individual peaks of activity lasting from 500,000 to one million years. Each super-episode shows chemical evidence of early larger degrees of melt formation followed by a pattern of waning volcanism as revealed by higher Ce/Yb and increasing epsilon Nd values. An important question is whether the Lathrop Wells cone (ca.

78,000 years old) represents the start of a new episode of eruption or whether it represents the end of an episode. Valentine and Perry (DN2002382703 at 214) suggest that it is the lone event in its episode because of the amount of time passed since the event without another eruption. However, because there was a one-million-year period of little to no activity following the eruption of the Crater Flat cones and nearly 2.5 million years of quiet between the eruption of basalt in SE Crater Flat and the one million years ago Crater Flat volcanoes, there is a strong possibility that the Lathrop Wells cone may herald the beginning of a new eruptive episode.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.3.11.2.1 and similar subsections which advocate that the volcanic system near Yucca Mountain represents a simple system that began with high volume activity and is now in a waning period. The implication of using the entire 11 million year record is that another super-episode of activity could occur, that the Lathrop Wells eruption may represent the beginning of a third super-episode, and that SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7×10^{-8} events/year, underestimates that probability, likely by two or more orders of magnitude.

Supporting reasons are given in Section 5 above and may be summarized as follows: Despite the 11 million year long record of basaltic volcanism near Yucca Mountain, DOE uses the past 5 million years of the record to conclude both that volcanism near Yucca Mountain is decreasing in volume and number of events and that future eruptions are very unlikely. These observations do not consider the entire history of volcanism as recorded in surface outcrops and core from borings about Yucca Mountain that define two super-episodes of volcanism. Rather than a single slowly dying igneous system, volcanism near Yucca Mountain occurred in two periods over the last 11 million years, each lasting 3 to 4 million years. Both super-episodes show chemical signs of a waning volcanic system toward the end of their history. The implication is that volcanism near Yucca Mountain does not record a single waning system but represents igneous activity that periodically starts and stops. Two periods of volcanic activity have already occurred at Yucca Mountain. Consideration of the complete record would support the proposition that the eruption at Lathrop Wells at 78,000 years ago represents the beginning of a third super-episode.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-152 - FOCUS ON UPPER CRUSTAL EXTENSION PATTERNS

1. A statement of the contention itself

SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7 x 10^{-8} events/year, underestimate that probability, likely by two or more orders of magnitude, because DOE focuses improperly on upper crustal extension patterns to explain volcano location and the timing of volcanic events.

2. A brief summary of the basis for the contention

Understanding the process of volcanism is critical for calculating the probability of future events. DOE clearly lacks this understanding and instead focuses on upper crustal extension patterns to explain volcano location and the timing of volcanic events. Contrary to DOE's arguments, the primary controls of the location of a volcanic field lie in the earth's mantle. The location of thermal anomalies, the topography at the base of the lithosphere, and patterns of mantle flow together control the location and timing of volcanism. Upper crustal structures and extension rates may be important for controlling the location of volcanoes whose magma resides for periods of time in the crust, but have less of an effect for basaltic magmas that rise quickly from their mantle source without stalling for long periods of time in the crust.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.11.2.2.5 at 2.3.11-23 states that "[f]or regional volcanism, no single base-case conceptual model is appropriate because the underlying physical processes that control the precise timing and location of volcanic events within a particular region remain uncertain (BSC 2004a, Section 6.3.1.6)." DOE clearly does not understand the processes that control volcanism. Nevertheless, DOE in SAR Subsections 2.2.2.2.3.1 at 2.2-96 through 98, 2.3.11.2.1.1 at 2.3.11-15 through 18, and 2.3.11.2.2.5 at 2.3.11-23 through 24 and related sections calls upon crustal structures and extension rates to explain the location and timing of volcanism. There is, however, a considerable literature that contradicts this conclusion for basaltic volcanism and suggests that thermal anomalies, mantle flow patterns, and topography at the base of the lithosphere explain the location and timing of volcanism. DOE ignores the role of the mantle and published geochemical and geophysical work that suggests that deep melting of asthenospheric mantle caused by upwelling associated with low-viscosity "pockets" and a step in lithospheric thickness explain the occurrence of volcanic activity near Yucca Mountain, and the episodic nature of volcanism. *See* Smith, E.I. and Keenan, D.L. (2005), "Yucca Mountain Could Face Greater Volcanic Threat," EOS, TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION, Vol. 86, No. 35 at 317; Smith, E.I., Conrad, C.P., Plank, T., Tibbetts, A., and Keenan, D. (2008), "Testing Models for Basaltic Volcanism: Implications for Yucca Mountain, Nevada," AMERICAN NUCLEAR SOCIETY, PROCEEDINGS OF THE 12TH INTERNATIONAL HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT CONFERENCE at 157-164; and Smith, *et al.* (2002), "Episodic Volcanism and Hot Mantle: Implications for Volcanic Hazard Studies at the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada," LSN# NEV000002718 at 4-10. Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164, cite articles that document a sharp change in the thickness of the North American plate producing a west facing buttress or keel in the lithosphere. Formed by Paleozoic and Mesozoic orogeny, a lithospheric boundary (the western margin of the North American Craton) and lithospheric thinning beneath the Sierra Nevada, the buttress lies either to the west or east of the Crater Flat area. Mantle flow caused by the buttress results in eddies or rolls that stir up areas of mantle close to the melting temperature. Mantle caught in upward flow melts due to pressure reduction and produces basaltic magma. A mantle eddy travels with the lithosphere and results in long-lived, geographically restricted magmatism. The shape and spacing of areas of hot mantle control the geographic extent and episodic nature of volcanism.

Numerical modeling of mantle flow provides information about the geometry of areas of upwelling, the effects of lithospheric steps, and the role of "hot-pockets" of mantle. *See* Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164. Mantle flow beneath North America is thought to be dominated by descent of a region of dense mantle rocks that lie about 1500 km below the Midwest and Eastern portion of the continent. This region, known as the "Farallon Slab" can be imaged seismically and was produced by subduction of dense oceanic lithosphere in the mantle interior off the western coast of North America prior to about 30 million years ago. Several studies have shown that descent of this slab produces a broad region of mantle down welling beneath the eastern portion of North America that depresses the Earth's surface and influences the westward motion of the North American plate. Numerical models of global-scale mantle flow confirm this flow pattern. Within the asthenosphere beneath the southwestern United States, these models show eastward directed flow toward the region of down welling. The rate of eastward flow at the base of the asthenosphere is up to 3 cm/yr. Because the overlying North American plate is moving westward at rates of about 2 cm/yr, the asthenosphere beneath the southwestern United States is shearing at rates of up to about 5 cm/yr. The vigorous shear flow occurring beneath the southwestern United States occurs within a region of asthenosphere that exhibits large lateral variations in material properties; these variations can be observed seismically. In particular, variations in seismic velocity observed by van der Lee and Frederiksen (*see* van der Lee, S. and Frederiksen, A. (2005), "Seismic Earth: Array Analysis of Broadband Seismograms," G. Nolet and A. Levander, Eds, GEOPHYSICAL MONOGRAPH SERIES, 157 at 67-80) at about 110 km show several trends that will influence the flow field of the asthenosphere beneath the southwestern United States. First, there is a general increase in seismic velocity moving from the southwest toward the continental interior. In general, faster seismic velocities are thought to represent denser and colder material, with lithospheric rocks featuring both. Thus, the eastward increase in seismic velocity is consistent with an increase in continental thickness moving from the Basin and Range province (with lithosphere shallower than 110 km) to the stable craton of the Midwest (with lithosphere thicker than 110 km). This increase in thickness has been observed by some authors to occur as a sharp increase in lithospheric thickness beneath the Nevada region. Second, several "pockets" of low-velocity anomalies are evident within the asthenosphere of the southwestern United States at a depth of 110 km. These "pockets" are consistent with portions of the asthenosphere that are unusually low-density, and therefore presumably hotter than the surrounding asthenosphere. These low velocity "pockets" of asthenosphere have also been observed in other tomographic studies of the western United States. Thus, the flow field within asthenosphere of the southwestern United States likely encounters both a sharp increase in the thickness of the cold lithosphere, as well as several "pockets" of unusually hot asthenosphere. Because the viscosity of mantle rocks is thought to vary strongly with temperature, the cold lithosphere and hot "pockets" can be thought of as high-viscosity and low-viscosity features, respectively. Both types of lateral viscosity variations may interact with the background mantle flow field to produce asthenospheric upwelling flow.

Numerical models examine how asthenospheric shear flow interacts with the lateral viscosity variations described above. To do this, Smith and Keenan (2005) at 317, and Smith, *et* *al.* (2008) at 157-164 examined flow within a two-dimensional layered structure that features a high-viscosity lithosphere and a low-viscosity asthenosphere. By pinning the surface lithosphere and imposing a velocity boundary condition on the base of the asthenosphere, Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 generated a shear flow within asthenospheric layer that models the one occurring beneath the western United States. To test the effect of varying lithospheric thickness on the flow field, Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 imposed lateral variations in the thickness of the lithospheric layer. To do this, Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 inserted a "cavity" of asthenospheric fluid into the lithospheric layer. Within the "cavity" region, the lithosphere is thin; outside of it the lithosphere is thicker. Shear flow in the asthenosphere generates circulation within the lithospheric "cavity." For a relatively narrow cavity, circulation develops within the cavity with an upwelling arm on the upstream side of the shear flow. For a wider cavity (or a step function increase in lithospheric thickness as expected for the southwestern United States), a small "vortex" develops in the corner of the cavity, with upwelling flow along the vertical face of the lithospheric step.

For the geometries of lithospheric variations that are expected for the southwestern United States, Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 found that the amplitude of upwelling may be up to about 5% of the shear flow magnitude, or about 0.25 cm/yr for the 5 cm/yr of shear flow expected for the southwestern United States. Lower viscosities of the upwelling fluid, which would be expected to accompany adiabatic melting, tend to amplify this effect. In a second test, Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 embedded a "pocket" of low-viscosity fluid within the asthenospheric layer. If this pocket is positioned immediately below the lithospheric layer, the faster velocities that the shear flow exerts on the base of the pocket generate a circulation within the low-viscosity pocket itself. Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 found that this circulation develops if the viscosity of the pocket is more than about 10 times less than the viscosity of the surrounding asthenosphere. If the pocket viscosity is 100 times smaller than the viscosity of the asthenosphere (which would be expected if the temperature of the pocket were about 200 degrees C hotter than the asthenosphere), then Smith and Keenan (2005) at 317, and Smith, *et al.* (2008) at 157-164 found that upwelling portion of the circulatory flow may feature upward velocities that are up to ~20% of the magnitude of asthenospheric shear. Thus, for the 5 cm/yr of shear flow, up to 1 cm/yr of upwelling is predicted within a low-viscosity "pocket" of asthenosphere. The low-densities of the hot fluid should augment this upwelling.

In summary, the vigorous shear flow that occurs beneath the western US can interact with lateral viscosity variations in both the lithospheric and asthenospheric layers to produce upwelling flow. At least two viable mechanisms, associated with heterogeneity in lithospheric thickness and asthenospheric viscosity, produce upwelling flow at maximum rates estimated to be ~1 cm/yr. Since both types of heterogeneity are present beneath the southwestern United States, either mechanism may produce the upwelling responsible for adiabatic melting in the asthenosphere. It is also possible that both mechanisms may be interacting to produce even more vigorous upwelling flow. These observations highlight the role of the mantle in controlling the location and timing of volcanism.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention takes issue with SAR Subsections 2.2.2.2.3.1, 2.3.11.2.1.1, 2.3.11.2.2.5, and related sections, which indicate wrongly that upper crustal extension is the main control of volcano location.

Geophysical and geochemical studies indicate that the mantle strongly controls the location and timing of volcanism near Yucca Mountain, and suggest that DOE does not understand the process of volcanism at Yucca Mountain. A proper understanding would indicate that SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7×10^{-8} events/year, underestimate that probability, likely by two or more orders of magnitude.

Supporting reasons are given in Section 5 above and may be summarized as follows: Understanding the process of volcanism is critical for calculating the probability of future events. DOE clearly lacks this understanding and instead focuses on upper crustal extension patterns to explain volcano location and the timing of volcanic events. Contrary to DOE's arguments, the primary controls of the location of a volcanic field lie in the earth's mantle. The location of thermal anomalies, the topography at the base of the lithosphere, and patterns of mantle flow together control the location and timing of volcanism. Upper crustal structures and extension rates may be important for controlling the location of volcanoes whose magma resides for periods of time in the crust, but have less of an effect for basaltic magmas that rise quickly from their mantle source without stalling for long periods of time in the crust.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one.

These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-153 - EXCLUSION OF DEATH VALLEY FROM VOLCANISM CALCULATIONS

1. A statement of the contention itself

SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7×10^{-8} events/year, underestimate that probability, likely by two or more orders of magnitude, because DOE does not include the Death Valley volcanic field in the Greenwater Range as part of the area to be considered for hazard calculations.

2. A brief summary of the basis for the contention

SAR Subsections 2.2.2.2, 2.2.2.2.3.1, 2.3.11.2.1.1, and 2.3.11.2.2.5 claim that the essential characteristics of the age and location of basaltic volcanism near Yucca Mountain were fundamentally understood when the PVHA was completed in 1996; however, this statement ignores volcanic activity in the Greenwater Range just 20 km south of buried basalt in Amargosa Valley. Volcanic rocks in the Greenwater Range have chemical, mineralogical and age similarities to those near Yucca Mountain and clearly represent the southern extension of the field of volcanoes about Yucca Mountain. This larger volcanic field, therefore, should be considered in any calculation of repository disruption by volcanic activity.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21 (c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE asserts that the size and shape of the volcanic field about Yucca Mountain is well known and that the hazard estimates made by experts of the PVHA panel in 1996 are still valid. Even after considering buried volcanic centers discovered after 1996, DOE claims in SAR Subsection 2.2.2.2 at 2.2-91 that "[t]he results also show that the effects of buried volcanic centers on the hazard estimate are modest (Section 2.3.11.2.2.6)**,** and the updated hazard estimate is robust and suitable for use in the license application and supporting TSPA calculations."

However, the volcanic field about Yucca Mountain should be expanded to include the volcanoes of the Greenwater Range near Death Valley. The following evidence supports this contention.

- First, volcanic activity in the Greenwater Range is associated with at least 17 volcanic centers and occurred after about 5 million years ago, contemporaneous with activity near Yucca Mountain. *See* "Geologic Map of California – Death Valley Sheet, with Index and Stratigraphic Nomenclature" (01/01/1974), LSN# DN2001741565, solo page.

- Second, basalt from Death Valley is very similar in major and trace element chemistry to basalt from Crater Flat. Trace-elements usually better characterize volcanic rocks than do major elements and are considered as fingerprints that are commonly used to correlate volcanic rocks from area to area. For comparison purposes, volcanic rocks are usually normalized to a standard rock like average ocean island basalt. Plots of trace elements versus normalized concentration show characteristic patterns that can be used to fingerprint and compare rocks from different volcanic fields. Comparing Death Valley and Crater Flat basalt on such a plot shows that they share a similar pattern. Especially characteristic is low Nb and high Rb, Th and U. *See* "Report of Research Activities in 2007 Prepared to Satisfy the Requirements of a Clark County Contract for Volcanic Hazard Assessment of the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada" (07/08/2008), LSN# CLK000000071 at 10-13.

- Third, Strontium (Sr) and neodymium (Nd) isotopes for Greenwater Range basalts (*see* Asmerom, Y., Jacobsen, S.B., and Wernicke, B.P., "Variations in Magma Source Regions During Large Scale Continental Extension, Death Valley Region, Western United States," EARTH AND PLANETARY SCIENCE LETTERS, Vol. 125 (1994) at 235-254) are identical to isotopic analyses from Crater Flat. Basalts in both areas have low epsilon Nd values (between -9.95 and -12), and high $^{87}Sr/^{86}Sr$ (0.7069-0.7073). *See* CLK000000071 at 10-13.

- Fourth, basalts in both the Crater Flat and Death Valley areas are similar in mineralogy and contain olivine as the major phenocrysts phase. Plagioclase is rare and usually occurs as microlites in the matrix.

In summary, the close geographic proximity to Crater Flat, similar age of eruption, similar mineralogy and major element chemistry, distinctive trace element patterns and distributions, and identical isotopic ratios demonstrate that Death Valley basalt in the Greenwater Range is closely associated with Yucca Mountain basalt. Hazard assessment for Yucca Mountain should consider the Greenwater volcanoes near Death Valley as part of field of volcanoes about Yucca Mountain. Calculations of repository disruption that ignore the Death Valley field underestimate the probability of repository disruption by igneous activity.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention takes issue with SAR Subsections 2.2.2.2, 2.2.2.2.3.1, 2.3.11.2.1.1, and 2.3.11.2.2.5, which claim that the essential characteristics of the age and location of basaltic volcanism near Yucca Mountain were fundamentally understood when the PVHA was completed in 1996, ignoring volcanic activity in the Greenwater Range just 20 km south of buried basalt in Amargosa Valley. Had this activity been considered, then SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7×10^{-8} events/year, would have had to be revised, as they underestimate that probability, likely by two or more orders of magnitude.

Supporting reasons are given in Section 5 above and may be summarized as follows: SAR Subsections 2.2.2.2, 2.2.2.2.3.1, 2.3.11.2.1.1, and 2.3.11.2.2.5 claim that the essential characteristics of the age and location of basaltic volcanism near Yucca Mountain were fundamentally understood when the PVHA was completed in 1996. This statement ignores volcanic activity in the Greenwater Range just 20 km south of buried basalt in Amargosa Valley. Volcanic rocks in the Greenwater Range have chemical, mineralogical and age similarities to those near Yucca Mountain and clearly represent the southern extension of the field of volcanoes about Yucca Mountain. This larger volcanic field, therefore, should be considered in any calculation of repository disruption by volcanic activity.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-154 - IGNEOUS EVENT PROBABILITY FOR 10,000 YEARS AND 1,000,000 YEARS

1. A statement of the contention itself

DOE wrongly assumes in SAR Subsections 2.3.11 and 2.3.11.1 and related subsections that its approach to estimating the probability of igneous events for the first 10,000 years is applicable to the probability estimate for the period from 10,000 to 1,000,000 years as well, because its approach fails to consider deep melting models or the entire period of volcanism from 11 million years to the present.

2. A brief summary of the basis for the contention

Despite legal requirements to consider compliance periods greater than 10,000 years, DOE essentially ignores this requirement in the license application. Compliance periods greater than 10,000 years are only briefly mentioned and DOE claims in SAR Subsections 2.3.11 that because of the overall volcanic stability of the region (in terms of recurrence rate, eruptive style, volume, and location relative to the repository) over the last 2 million years, this same estimated annual frequency of intersection is also valid for evaluations over time periods that extend beyond 10,000 years. This statement does not consider deep melting models or the entire period of volcanism from 11 million years ago to the present.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Compliance periods as long as one million years must be considered for volcanic probability calculations. However, DOE essentially ignores this requirement. In SAR Subsection 2.3.11 and similar sections, DOE claims that calculations for the 10,000-year period also apply for longer compliance post-closure periods, but bases this conclusion on a model of shallow melting in the lithospheric mantle and observations of volcanism over the past 5 million years. This is explained in detail in contentions NEV-SAFETY-150 and NEV-SAFETY-151. In brief, a shallow melting model infers that volcanic activity will be less vigorous in the future and that the number of future events will be small and infrequent, but work by Smith, *et al.* (2002), "Episodic Volcanism and Hot Mantle: Implications for Volcanic Hazard Studies at the Proposed Nuclear Waste Repository at Yucca Mountain," LSN# NEV000002718 at 4-10, Smith, E.I. and Keenan, D.L. (2005), "Yucca Mountain Could Face Greater Volcanic Threat," EOS, TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION, Vol. 86, No. 35 at 317, and Smith, E.I., Conrad, C.P., Plank, T., Tibbetts, A., and Keenan, D. (2008), "Testing Models for Basaltic Volcanism: Implications for Yucca Mountain, Nevada," AMERICAN NUCLEAR SOCIETY, PROCEEDINGS OF THE 12TH INTERNATIONAL HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT CONFERENCE at 157-164, and references therein, show persuasively that deep melting models are more relevant to the Yucca Mountain area. Deep melting models predict a more active volcanic future with a higher probability that volcanism will become more vigorous. The deep melting model is especially important for the one-million-year compliance period because peaks of activity recorded for the Yucca Mountain area have occurred every one to two million years. Therefore, a new episode of activity is likely to occur during the longer post-closure compliance period. Also, considering the entire record of volcanism from 11 million years to the present demonstrates that in the Yucca Mountain area two super-episodes of activity occurred each lasting three to four million years. *See* "Report of Research Activities in 2007 Prepared to Satisfy the Requirements of a Clark County Contract for Volcanic Hazard Assessment of the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada" (07/08/2008), LSN# CLK000000071 at 14-17. Moreover, when considering the last 11 million years the Yucca

Mountain area is far from being volcanically stable as claimed in SAR Subsection 2.3.11. The implications of using deep melting models and the entire volcanic record are that future volcanic activity could be just as intense as past activity and that a third super-episode may occur. In fact, data and analyses are consistent with the proposition that the Lathrop Wells cone that erupted 78,000 years ago after nearly one million years of quiescence may represent the beginning of the third super-episode.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention takes issue with SAR Subsections 2.3.11 and 2.3.11.1 and related sections, which wrongly assume that DOE's approach to estimating the probability of igneous events for the first 10,000 years is applicable to the probability estimate for 1,000,000 years as well. Had DOE not made this assumption, and considered the factors discussed above, SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related sections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7 x 10^{-8} events/year, would have had to be revised, as they underestimate that probability, likely by two or more orders of magnitude.

Supporting reasons are given in Section 5 above and may be summarized as follows: Despite legal requirements to consider compliance periods greater than 10,000 years, DOE essentially ignores this requirement in the license application. Compliance periods greater than 10,000 years are only briefly mentioned and DOE claims in SAR Subsections 2.3.11 at 2.3.11-1 and 2.3.11.1 at 2.3.11-9 that because of the overall volcanic stability of the region (in terms of recurrence rate, eruptive style, volume, and location relative to the repository) over the last 2 million years, this same estimated annual frequency of intersection is also valid for evaluations over time periods that extend beyond 10,000 years. This statement does not consider deep melting models or the entire period of volcanism from 11 million years to the present.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-155 - 11-MILLION YEAR VS. 5-MILLION YEAR VOLCANISM DATA

1. A statement of the contention itself

DOE's approach to determining the frequency of future igneous events wrongly ignores the data set obtained from core, which along with surface data provides a record of volcanism back to 11 million years that requires consideration, and wrongly relies instead on the chemistry of surface basalt erupted over the past 5 million years. This approach obscures long-term trends and provides an inaccurate prediction of future events.

2. A brief summary of the basis for the contention

Contrary to the claim in SAR Subsection 2.3.11.2.1.1 that the chemistry of buried basalt bodies is essentially the same as basalt exposed on the surface, buried basalt contains rock types not found or rare at the surface. Buried basalt observed in core from borings in Crater Flat, Amargosa Valley and Jackass Flat reveal compositions not found or rare at the surface. Combining core with surface data reveals a geologic history back to 11 million years characterized by two super-episodes of volcanism each independently showing major and trace element signs of a developing and then dying system that may be replicated in the future. DOE ignores the rich data set obtained from core and relies on the chemistry of surface basalt erupted over the past 5 million years to make assumptions about the frequency of future events. This approach obscures long-term trends and provides an inaccurate prediction of future events.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation that the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.11.2.1.1 at 2.3.11-17 states that, "Major-element, trace-element and isotopic data were obtained from the buried basalt bodies and indicate that all are broadly basaltic in composition with typical SiO_2 contents of 42-50%. These geochemical results are consistent with geochemical analyses of basalt samples from surface exposures near Yucca

Mountain (Perry and Bowker 1998)." However, work by "Report of Research Activities in 2007 Prepared to Satisfy the Requirements of a Clark County Contract for Volcanic Hazard Assessment of the Proposed Nuclear Waste Repository at Yucca Mountain, Nevada" (07/08/2008), LSN# CLK000000071 at 9-10 indicates that:

1. Basalt collected from borings in Crater Flat and the Amargosa Valley is quite different in chemistry when compared to basalt in the 1.0 million year old cinder cones in Crater Flat.
2. Basalt in core has a larger range of SiO_2 contents (43 to 52 wt. %), compared with Crater Flat (47-50 wt. %), and lower light rare-earth element concentrations.
3. Three rock types were observed in core but are not found at the surface:
    a. Lower silica basanites in USW-VA-1;
    b. Coarse-grained quartz diorite dikes in boring USW-VA-1 at a depth of 556.7 feet; and
    c. Basalt with 2-3 mm clinopyroxene crystals in JF-5.

Yucca Mountain core provides a unique opportunity to view the volcanic history of the Yucca Mountain area back to 11 million years ago. Unlike previous work that limits analysis to post-5 million-year basalts (*see* "Tectonically Controlled, Time-Predictable Basaltic Volcanism From a Lithospheric Source" (02/07/2007), LSN# DN2002382703 at 1-22), the core provides a record from the beginning of basalt volcanism 11 million years ago. Rather than a pattern of decreasing volume and waning activity, the record from the core combined with data from surface exposures reveals two episodes of activity separated by a several-million-year period of relative quiet. Within each episode, volcanism occurred periodically with individual peaks of activity lasting from 500,000 to one million years. Each super-episode shows chemical evidence of early larger degrees of melt formation followed by a pattern of waning volcanism as revealed by higher Ce/Yb and increasing epsilon Nd values. An important question is whether the Lathrop Wells cone (ca. 78,000 years old) represents the start of a new episode of eruption or whether it represents the end of an episode. Valentine and Perry (DN2002382703 at 19) suggest that it is the lone event in its episode because of the amount of time passed since the event without another eruption. However, because there was a one-million-year period of little to no activity following the eruption of the Crater Flat cones and nearly 2.5 million years of quiet between the eruption of basalt in SE Crater Flat and the one-million-year old Crater Flat volcanoes, there is a strong possibility that the Lathrop Wells cone may herald the beginning of a new eruptive episode.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the claim in SAR Subsection 2.3.11.2.1.1 that the chemistry of buried basalt bodies is essentially the same as basalt exposed on the surface, and the related claim that predictions of future igneous events may rely on surface data without full and careful consideration of core data. Had DOE considered core data, which provides a record from the beginning of basalt volcanism 11 million years ago, SAR Subsections 2.2.2.2.3.1, 2.3.11.2.2 and related subsections, which indicate that the probability of igneous activity disrupting a repository drift is 1.7 x 10^{-8} events/year, would have had to be revised as they underestimate that probability, likely by two or more orders of magnitude.

Supporting reasons are given in Section 5 above and may be summarized as follows: Contrary to the claim in SAR Subsection 2.3.11.2.1.1 that the chemistry of buried basalt bodies is essentially the same as basalt exposed on the surface, buried basalt contains rock types not found or rare at the surface. Buried basalt observed in core from borings in Crater Flat, Amargosa Valley and Jackass Flat reveal compositions not found or rare at the surface. Combining core with surface data reveals a geologic history back to 11 million years characterized by two super-episodes of volcanism each independently showing major and trace element signs of a developing and then dying system that may be replicated in the future. DOE ignores the rich data set obtained from core and relies on the chemistry of surface basalt erupted over the past 5 million years to make assumptions about the frequency of future events. This approach obscures long-term trends and provides an inaccurate prediction of future events.

NEV-SAFETY-156 - ALTERNATIVE IGNEOUS EVENT CONCEPTUAL MODELS

1. A statement of the contention itself

DOE's assessment of the frequency of igneous events does not consider appropriate alternative conceptual models that are consistent with available data and current scientific understanding, with the result that uncertainty is underestimated and not properly characterized.

2. A brief summary of the basis for the contention

SAR Subsection 2.2.2.3 and related subsections indicate that the license application relies on the results of the 1996 report of Probabilistic Volcanic Hazard Assessment (PVHA) expert panel report released in 1996 as the basis for hazard assessment. Except for new work on the tectonics of the Crater Flat area and a brief mention of buried basalt, DOE has not updated the PVHA findings, but still bases its conclusions on this out-dated report. The PVHA panel of experts based their results on the assumption of shallow melting to produce basaltic magma. Using this assumption results in an underestimate of the probability of repository disruption, and at the least, the alternative model whereby melting to produce basalt occurs in the asthenosphere should have been included in the total systems performance assessment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable assurance or expectation the materials described in the application can be disposed of without unreasonable

risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). Moreover, 10 C.F.R. § 63.114(c) explicitly requires consideration to be given to alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and requires an evaluation of the effects that alternative conceptual models have on the performance of the geologic repository in order that, as required by 10 C.F.R. §§ 63.102(h) and 63.304, uncertainty is properly estimated and accounted for. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE relies heavily on the "Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada, BA0000000-01717-2200-00082, Revision 0" (06/26/1996), LSN# DEN000861156 ("PVHA") as a basis for calculations of the intersection of the repository footprint by an igneous event. The PVHA report is now out-of-date and does not consider alternative models for volcanism. Indeed, SAR Subsection 2.3.11.2.2.5 at 2.3.11-23 states that "no single base-case conceptual model is appropriate." The 1996 PVHA panel used the assumption that melting to produce basaltic magma is shallow in the lithospheric mantle. The SAR discusses the assumption that basaltic magmas were generated in the shallow lithospheric mantle mainly in SAR Subsections 2.2.2.2.3.1 and 2.3.11.2.2. In SAR Subsection 2.2.2.2.3.1 at 2.2-97, and repeated in Subsection 2.3.11.2.2.5 at 2.3.11-23, it is stated that,

> The PVHA experts generally view volcanism in the Yucca Mountain region as a regional-scale phenomenon resulting from melting processes in the upper lithospheric mantle. . . .
>
> Analyses of magmatic processes in the Yucca Mountain region generally indicate that the magnitude of mantle melting has significantly decreased since the middle Miocene. The analyses also suggest that melts in the past few million years were generated within relatively cool ancient lithospheric mantle (compared to asthenospheric mantle), which is a factor that may contribute to the relatively small and decreasing volume of basaltic melt erupted in the Yucca Mountain region since the Miocene period (BSC 2004k, Section 6.3.3).

These statements are contrary to published research that clearly points out that melting of lithospheric mantle to produce basalt late in an extensional event, as DOE assumes, is difficult if not impossible. In several papers (*see* "Episodic Volcanism and Hot Mantle: Implications for Volcanic Hazard Studies at the Proposed Nuclear Waste Repository at Yucca Mountain" (4/1/2002), LSN# NEV000002718 at 4-10; Smith, E.I. and Keenan, D.L. (2005), "Yucca Mountain Could Face Greater Volcanic Threat," EOS, TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION, Vol. 86, No. 35 at 317; Smith, E.I., Conrad, C.P., Plank, T., Tibbetts, A., and Keenan, D. (2008), "Testing Models for Basaltic Volcanism: Implications for Yucca Mountain, Nevada," AMERICAN NUCLEAR SOCIETY, PROCEEDINGS OF THE 12TH INTERNATIONAL HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT CONFERENCE AT 157-164), it was demonstrated that lithospheric mantle does not melt to produce basalt about Yucca Mountain.

Peridotite of the mantle lithosphere is too cold to melt. The only components that could melt are those with a lower solidus temperature than dry peridotite. These components were probably totally melted during previous events that produced the voluminous rhyolite ash-flow tuffs that now form Yucca Mountain.

Calculations of melting depths (*see* "A Mantle Melting Profile Across the Basin and Range, SW USA" (1/22/2002), LSN# NEV000004173 at ECV 5-1 through ECV 5-21; NEV000002718 at 4-10; Smith, *et al.* (2008) at 157-164; and "Yucca Mountain Project Terry Plank Lamont-Doherty Earth Observatory Report on Activities from January 26, 2008 - February 26, 2008" (2/26/2008), LSN# NEV000005026 at 1-4) indicate that basalts at Yucca Mountain were produced by melting at depths of 115-133 km within the asthenospheric mantle. These calculations were done assuming a dry mantle, but even if water contents of 1-4.5 wt. % are considered melting is still deep in the asthenosphere (*see* NEV000005026 at 1-4; and Smith, *et al.* (2008) at 157-164). Depth of melting calculations used the Fe-Na (*see* NEV000004173 at ECV 5-1 through ECV 5-21) and Silica (*see* NEV000005026 at 1-4) geobarometers and were calibrated using basalt samples from the Big Pine Volcanic Field in eastern California. In the Big Pine example, both geobarometers placed melting in a zone of low-velocity (high temperature) asthenosphere at depths of 50 to 75 km (*see* NEV000005026 at 1-4). These calculations place high confidence in melting depths calculated using both the Fe-Na and Silicon barometers and strongly indicate that melting to produce basaltic magma is in the deep asthenosphere and not in the lithospheric mantle.

Prior to ten million years ago, shallow melting did occur in the Great Basin area, including in the Crater Flat Volcanic Field immediately adjacent to Yucca Mountain. Harry, D.L., Sawyer, D.S. and Leeman, W.P. (1993), "The Mechanics of Continental Extension in

Western North America: Implications for the Magmatic and Structural Evolution of the Great Basin," EARTH AND PLANETARY SCIENCE LETTERS, Vol. 117 at 59-71, and Harry, D.L. and Leeman, W.P. (1995), "Partial Melting of Melt Metasomatized Subcontinental Mantle and the Magma Source Potential of the Lower Lithosphere," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 100 at 10255-10269 examined the effects of extension in the Great Basin in relation to melting of lithospheric mantle (shallow melting). They determined that certain components commonly found in the lithospheric mantle (mafic veins or water rich minerals) could be melted during the initial phases of extension. This would explain the widespread silica-rich volcanism during Oligocene time (33.7-23.8 million years ago). These studies also determined that the early melting events exhausted the lower melting temperature components in the lithospheric mantle. Consequently any volcanism after about 10 million years ago could not be from this source and must be from asthenospheric (deep) melting. Gallagher, K. and Hawkesworth, C.J. (1992), "Dehydration Melting and the Generation of Continental Flood Basalts," NATURE, Vol. 358 at 57-59, and Hawkesworth, C., Turner, S., Gallagher, K., Bradshaw, T. and Rogers, N. (1995), "Calc-Alkaline Magmatism, Lithospheric Thinning, and Extension in the Basis and Range," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 100 at 10271-10286 did a regional study of the Great Basin to determine the effects of the presence of water on subsurface melting. Their study concluded that lithospheric mantle will only melt with the presence of water (0.5 wt. %) and that lithospheric mantle will melt before asthenospheric mantle. They also concluded that the early voluminous volcanic activity likely depleted the water component that made lithospheric mantle melting possible. In addition, the large scale extension throughout the region caused thinning of the lithospheric mantle. This allowed upwelling of the asthenospheric mantle. The resulting decrease in pressure in the asthenosphere created conditions favorable to melting of this material.

The depletion of water and resulting thinning of the lithosphere due to extension led the authors to the conclusion that little if any lithospheric mantle melting could have occurred more recent than 10 million years ago. Deep melting models are a more accurate way to explain the volcanism that occurred during the last 10 million years.

DOE uses an isotopic data set that shows that basalt near Crater Flat has higher Sr and lower Nd isotopic signatures than expected for asthenospheric sources. They use this data to support the shallow melting model. This isotopic data does not establish shallow melting because it is not inconsistent with deep melting. Lee, C.-T., Yin, Q., Rudnick, R.L., Chesley, H.T. and Jacobsen, S.B. (2000), "Osmium Isotopic Evidence for Mesozoic Removal of Lithospheric Mantle Beneath the Sierra Nevada, California," SCIENCE, Vol. 289 at 1912-1916 suggested that basalts with the isotopic signatures found in the Crater Flat volcanic field could be related to contamination either by lithospheric mantle or by subducted crustal material. A later study by Lee, C.T., Yin, Q,, Rudnick, R.L. and Jacobson, S.B. (2001), "Preservation of Ancient and Fertile Lithospheric Mantle Beneath the Western United States," NATURE, Vol. 111 at 69-73 determined that Archean (>2.7 billion years old) crust may be present beneath the southern Great Basin area. Melting of Archean crust or contamination from it could account for the isotopic signatures.

In recent years there have been numerous studies based on a variety of data**,** all of which point to the presence of deep melting in the Yucca Mountain area and throughout most of the central Great Basin (reported in NEV000004173 at ECV 5-1 through ECV 5-21, and Smith, *et al.* (2008) at 157-164). Indeed, DOE originally suggested melting of the asthenosphere to produce basalt. Perry and Crowe, "Geochemical Evidence for Waning Magmatism and Polycyclic Volcanism at Crater Flat, Nevada" (04/20/1992), LSN# DN2001597248 at 1-10 noticed steep rare earth element patterns, which indicate deep melting. Furthermore, several geophysical studies (*see* van der Lee, S. and Nolet, G. (1997), "Upper Mantle S Velocity Structure of North America," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 102 at 22815-22838; Savage, M.K. and Sheehan, A.F. (2000), "Seismic Anisotropy and Mantle Flow from the Great Basin to the Great Plains, Western United States," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 105 at 13725-13734; and Lowry, A.R., Ribe, N.M. and Smith, R.B. (2000), "Dynamic Elevation of the Cordillera, Western United States," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 105 at 23371-23390) all support hotter than normal mantle at depth in the central Nevada region and thus deep melting.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges DOE's reliance on one central conceptual model of volcanism, as described mainly in SAR Subsections 2.2.2.2.3., 2.3.11.2.2, 2.2.2.2.3.1, and 2.3.11.2.2, without including full consideration of an alternative conceptual model that is more in accord with, and is certainly consistent with, available data and current scientific understanding.

Supporting reasons are given in Section 5 above and may be summarized as follows: SAR Subsection 2.2.2.3 and related subsections state that the license application relies on the results of the Probabilistic Volcanic Hazard Assessment expert panel report released in 1996 (PVHA) as the basis for hazard assessment. Except for new work on the tectonics of the Crater Flat area and a brief mention of buried basalt, DOE has not updated the PVHA findings, but still bases its conclusions on this out-dated report. The PVHA panel of experts based their results on the assumption of shallow melting to produce basaltic magma. Using this assumption results in an underestimate of the probability of repository disruption, and at the least, the alternative model whereby melting to produce basalt occurs in the asthenosphere should have been included in the total systems performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-157 - IGNEOUS EVENT DATA IN THE TSPA

1. A statement of the contention itself

DOE's assessment of the frequency of igneous events in the LA ignores information and analyses since 1996 which would, if considered, have required a significant change in the total systems performance assessment, and as a result, the LA is not complete and accurate in all material respects.

2. A brief summary of the basis for the contention

SAR Subsection 2.2.2.3 and related sections indicate that the license application relies on the results of the Probabilistic Volcanic Hazard Assessment expert panel report released in 1996 (PVHA) as the basis for hazard assessment. Except for new work on the tectonics of the Crater Flat area and a brief mention of buried basalt, DOE has not updated the PVHA findings, but still bases its conclusions on this out-dated report. Much research has been done since 1996 by DOE, NRC, the State of Nevada and Clark County that is pertinent to hazard analysis but is not considered in the license application.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.10 requires that the application be complete and accurate in all material respects and include all information with known significant implications for the public health and safety. Also, 10 C.F.R. § 63.21(a) requires that the application be as complete as possible in

light of information reasonably available at the time of docketing. This contention alleges violations of these provisions.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Since 1996, DOE, NRC, the State of Nevada and Clark County have done much work that is pertinent to volcanic hazard analysis at Yucca Mountain but is not considered in the license application. This includes:

"Shallow Plumbing Systems for Small-Volume Basaltic Volcanoes, LA-UR-06-5978" (04/25/2007), LSN# DN2002499936;

"Localization of Volcanic Activity: 2 Effects of Pre-Existing Structure in Basaltic Fields" (01/31/2007), LSN# DN2002377046;

"Tectonically Controlled, Time-Predictable Basaltic Volcanism from a Lithospheric Source" (02/07/2007), LSN# DN2002382703;

"Eruptive Styles and Inferences on Plumbing Systems at Hidden Cone and Little Black Peak Scoria Cone Volcanoes (Nevada, U.S.A.), LA-UR-06-7130" (01/16/2007), LSN# DN2002375513;

"Eruptive and Geomorphic Processes at the Lathrop Wells Scoria Cone Volcano, LA-UR-06-5184" (11/30/2006), LSN# DN2002452726;

"Small-Volume Basaltic Volcanoes: Eruptive Products and Processes, and Post-Eruptive Geomorphic Evolution in Crater Flat (Pleistocene), Southern Nevada" (2006), LSN# DN2002451433;

"Decreasing Magmatic Footprints of Individual Volcanoes in a Waning Basaltic Field, LA-UR-06-3145" (2006), LSN# DN2002453292;

Valentine, G.A., Krogh, K.E.C. (2006), "Emplacement of shallow dikes and sills beneath a small basaltic volcanic center - the role of pre-existing structure (Paiute Ridge, southern Nevada, USA)," EARTH AND PLANETARY SCIENCE LETTERS, Vol. 246 at 217-230;

"Early-time multiphase interactions between basaltic magma and underground openings at the proposed Yucca Mountain radioactive waste repository" (11/30/2005), LSN# DN2002318671;

"Scoria cone construction mechanisms, Lathrop Wells volcano, southern Nevada, LA-UR-04-8750" (02/15/2005), LSN# DN2001909760;

"Uncovering Buried Volcanoes at Yucca Mountain" (11/22/2005), LSN# DN2002456023.

The license application also omits an important report completed by NRC contractors that describes water contents in basaltic magma from Crater Flat and the Lathrop Wells cone.

"Pre-Eruptive Magmatic Temperatures, Oxygen Fugacities, and Volatile Contents for Trachybasalts from Lathrop Wells and Red Cone, Crater Flat, Nevada, USA" (2005), LSN# NEV000005025 at 1-27.

Another major omission from the license application is the report from the "Probabilistic Volcanic Hazard Analysis Update (PVHA-U) for Yucca Mountain, Nevada Rev. 01" (09/02/2008), LSN# DEN001601965. This panel uses eight of the ten experts from the first panel and two additional experts. The report of this panel is not considered in the license application. PVHA-U provides new estimates of the probability of repository disruption taking into account the buried basalt and using more modern statistical techniques. Despite the possibility that changes in hazard assessment models and calculations are modest, it is critical that this report be included in the license application.

Omission of all this work results in an underestimate of the probability of repository disruption and of the related uncertainties, which in turn leads to an erroneous total systems performance assessment.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention states that the application, especially SAR Subsection 2.2.2.3 and related sections, ignores information and analyses since 1996 which would, if considered, have required a significant change in the total systems performance assessment. Supporting reasons are given in Section 5 above and may be summarized as follows: SAR Subsection 2.2.2.3 and related subsections indicate that the license application relies on the results of the "Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada (PVHA), BA0000000-01717-2200-00082, Revision 0" (06/26/1996), LSN# DEN000861156 expert panel report released in 1996 as the basis for hazard assessment. Except for new work on the tectonics of the Crater Flat area and a brief mention of buried basalt, DOE has not updated the PVHA findings, but still bases its conclusions on this out-dated report. Much research has been done since 1996 by DOE, NRC, the State of Nevada and Clark County that is pertinent to hazard analysis but is not considered in the license application.

NEV-SAFETY-158 - GEOPHYSICAL DATA IN DOE'S VOLCANIC MODEL

1. A statement of the contention itself

High-quality geophysical data is necessary to answer the fundamental question as to whether volcanoes are primarily controlled by upper crustal structure or mantle. DOE's approach to predicting the location and frequency of future eruptions, as reflected in SAR Subsection 2.2.2.2.3.1 and related subsections, relies heavily on upper crustal structures and the local stress field, but does not provide sufficient geophysical data to support this model. This is inadequate because high-quality geophysical data are necessary to confirm or rule out the proposition, supported by the currently available data, that the primary control of the location of a basaltic field near Yucca Mountain is asthenospheric mantle processes.

2. A brief summary of the basis for the contention

Although geophysical studies are mentioned in SAR Subsection 2.2.2.1.2 as a way to identify and characterize the orientation of faults in the subsurface, the license application lacks geophysical data to document models proposed by DOE that use upper crustal structure and the local stress field to explain the location of volcanoes in the Yucca Mountain area. Geophysical studies are also critical for testing and comparing deep versus shallow melting models by revealing the location of low-viscosity zones (hot zones) in the crust and mantle that might contain magma or rock close to the melting temperature. Furthermore, identifying patterns of mantle circulation and the nature of the topography at the base of the lithosphere are important for describing the geometry of volcanic source zones which ultimately control the location and shape of volcanic fields at the surface.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires adequate support for the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113, and this performance assessment must include consideration of the probability and consequences of events and processes identified under 10 C.F.R. § 63.21(c)(9). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 2.2.2.2.3.1 at 2.2-97 and related subsections indicate that DOE relies heavily on an assumption of control exerted by upper crustal structures and the local stress field to predict the location of future eruptions. For example DOE states,

> The Quaternary volcanoes in the Crater Flat basin and their proximities to Yucca Mountain (Figure 2.2-24) result in the Crater Flat cluster playing a major role in assessing the potential for future volcanism at Yucca Mountain. Research on the Crater Flat structural domain, published largely since the PVHA was conducted (Fridrich 1999), provides evidence that the northeastern and southwestern portions of the basin have different extensional histories that may have influenced the location of basaltic volcanism within the basin (BSC 2004k, Section 6.4).

As noted from SAR Subsection 2.3.11.2.1.1 at 2.3.11-17, specific predictions about the location of future volcanoes are based almost entirely on the location of upper crustal structures and extension rate:

> Thus, the Crater Flat volcanoes, including Lathrop Wells volcano, show that close spatial and temporal relationships exist between areas of extension and volcanism throughout the Crater Flat domain (Fridrich, *et al.* 1999, p. 211). The occurrence of three episodes of post-Miocene volcanism in the more extended part of the Crater Flat domain suggests future volcanism is more likely to occur in southwestern Crater Flat and less likely to occur at Yucca Mountain, which lies outside of the more extended part of the Crater Flat domain (BSC 2004a, Section 6.1.1.1).

Without geophysical data to determine the subsurface geometry of faults, the thickness and geometry of the crust and lithospheric mantle, and the identification of low velocity zones (hot areas) in the crust and mantle, conclusions that relate volcano location to upper crustal structure and the local stress state are not supportable. Geophysical studies provide important information regarding prediction of the location of future volcanism. The two most important controls of volcano location are mantle source zones and crustal structures and stress fields. More evolved magmas that have a long crustal residence times (rhyolite to andesite) may have a strong upper crustal control, but mafic magmas that melt mantle and rise quickly through the crust to the surface may not be affected by either crustal structures or local stress fields. In reality it is uncommon for basalt dikes or volcanoes to locate on faults. *See* "Volcanism Studies Related to the Probabilistic Volcanic Hazard at Yucca Mountain for the Period 1986-1996" (01/01/1997), LSN# NEV000000704 at 1-14. The shape of a basaltic volcanic field more strongly reflects the geometry of the melting anomaly (source zone) than weak local stress fields or shallow upper crustal faults.

Geophysical studies have been used in other volcanic fields close to Yucca Mountain to determine lithospheric thickness, locate hot zones (low velocity) in the mantle and determine whether basalt magma was generated in the lithosphere or asthenosphere. Yang, Y. and Forsyth, D.W. (2006), "Rayleigh Wave Phase Velocities, Small-Scale Convection and Azimuthal Anisotropy Beneath Southern California," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 111, No. 7, B07306, prepared a model of seismic shear wave velocities across California at 36.5 degrees north latitude across the Big Pine Volcanic Field. The study revealed a volcanic source zone (low-velocity zone) that extends from the base of the lithosphere at a depth of 50 km to 75 km. Melting depths calculated by both the Na-Fe and Silica geobarometers place melting within this zone of hot mantle. *See* "Yucca Mountain Project Terry Plank Lamont-Doherty Earth Observatory Report on Activities from January 26, 2008 - February 26, 2008" (2/26/2008), LSN# NEV000005026 at 1-4. The study also revealed a high-velocity zone just west of Big Pine at a depth of 75 to 175 km that may represent a fragment of the subducted Farallon Plate. Yang and Forsyth (2006) suggest that this plate generated sufficient mantle circulation to localize volcanism at Big Pine. It is a critical omission of DOE’s research strategy and the license application that this type of information is not available for Yucca Mountain.

Conrad ("Characterization of Three-Dimensional Mantle Flow Beneath Nevada: Implications for Volcanic Hazard, Technical Progress Report for May 2008" (06/10/2008), LSN# NEV000005021 at 1-19, and "Technical Progress Report for November 2007" (12/03/2007), LSN# NEV000004225 at 1-5) provides data critical for understanding the occurrence of volcanism in the Yucca Mountain area. Studies of mantle circulation and the effects of lithospheric topography are important for understanding why volcanoes occur where they do. This type of study was not considered by the PVHA panel and is not included in the license application. This is another major omission and is grounds for questioning DOE's conclusions regarding the crustal control of volcanism.

In detail, Conrad (NEV000005021 at 1-19; NEV000004225 at 1-5) has shown that the mantle beneath the Great Basin and Yucca Mountain is rapidly shearing at rates of up to 5 cm/year. Moreover, mantle circulation and topography at the base of the lithosphere produce mantle upwelling (and the potential for melting) in the Yucca Mountain area. Mantle flow beneath North America is thought to be dominated by descent of a region of dense mantle rocks that lie about 1500 km below the Midwest and Eastern portion of the continent. This structure, known as the "Farallon Slab" can be imaged seismically and was produced by subduction of dense oceanic lithosphere in the mantle interior off the western coast of North America prior to about 30 million years ago. *See* Bunge, H.-P., and Grand, S.P. (2000), "Mesozoic Plate-Motion History below the Northeast Pacific Ocean from Seismic Images of the Subducted Farallon Slab," NATURE, Vol. 405 at 337-340. Several studies have shown that descent of this slab produces a broad region of mantle downwelling beneath the eastern portion of North America that depresses the Earth's surface (*see* Conrad, C.P., Lithgow-Bertelloni, C. and Louden, K.E. (2004), "Iceland, the Farallon Slab, and Dynamic Topography of the North Atlantic," GEOLOGY, Vol. 32 at 177-180) and influences the westward motion of the North American plate (*see* Bokelmann, G.H.R. (2002), "Which Forces Drive North America?" GEOLOGY, Vol. 30 at 1027–1030). Numerical models of global-scale mantle flow (*see* Conrad, C.P., Behn, M.D. and Silver, P.G. (2007), "Global Mantle Flow and the Development of Seismic Anisotropy: Differences Between the Oceanic and Continental Upper Mantle," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 112 at B07317) confirm this flow pattern. Within the asthenosphere beneath the southwest U.S., these models show eastward-directed flow toward the region of downwelling. The rate of eastward flow at the base of the asthenosphere can be up to 3 cm/yr. Because the overlying North American plate is moving westward with rates of about 2 cm/yr, the asthenosphere beneath the southwestern U.S. is shearing at rates of up to about 5 cm/yr. This basic pattern of asthenospheric shear produces a seismically fast anisotropic fabric for asthenospheric rocks with an approximately east-west orientation. This orientation is observed by SKS splitting observations of anisotropy, thus confirming the presences of strong shear flow beneath the western U.S. *See* Becker, T.W., Schulte-Pelkum, V., Blackman, D.K., Kellogg, J.B. and O'Connell, R.J. (2006), "Mantle Flow Under the Western United States from Shear Wave Splitting," EARTH AND PLANETARY SCIENCE LETTERS, Vol. 247 at 235-251.

The vigorous shear flow occurring beneath the southwestern U.S. occurs within a region of asthenosphere that exhibits large lateral variations in the material properties; these variations can be observed seismically. In particular, variations in seismic velocity observed by van der Lee, S. and Frederiksen A. (2007), "Surface Wave Tomography Applied to the North America Upper Mantle, in Seismic Earth: Array Analysis of Broadband Seismograms," G. Nolet and A. Levander, Eds, GEOPHYSICAL MONOGRAPH SERIES, 157 at 67-80, at about 110 km show several trends that will influence the flow field of the asthenosphere beneath the southwestern U.S.

First, there is a general increase in seismic velocity moving from the southwest toward the continental interior. In general, faster seismic velocities are thought to represent denser and colder material, with lithospheric rocks featuring both. Thus, the eastward increase in seismic velocity is consistent with an increase in continental thickness moving from the Basin and Range province (with lithosphere shallower than 110 km) to the stable craton of the Midwest (with lithosphere thicker than 110 km). This increase in thickness has been observed by some authors to occur as a sharp increase in lithospheric thickness beneath the Yucca Mountain region. *See* Zandt, G., Myers, S.C., and Wallace, T.C. (1995), "Crust and Mantle Structure Across the Basin and Range-Colorado Plateau boundary at 37 N Latitude and Implications for Cenozoic Extensional Mechanism," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 100 at 10529-10548; and "A Mantle Melting Profile Across the Basin and Range, SW USA" (01/22/2002), LSN# NEV000004173 at 1-21**.** Second, several "pockets" of low-velocity anomalies are evident within the Great Basin asthenosphere at 110 km depth. These "pockets" may represent portions of the asthenosphere that are unusually low-density, and therefore presumably hotter than the surrounding asthenosphere. These low-velocity "pockets" of asthenosphere have also been observed in other tomographic studies of the western U.S. *See, e.g*., Dueker, K., Yuan, H. and Zurek, B. (2001), "Thick-Structured Proterozoic Lithosphere of the Rocky Mountain Region," GSA TODAY, Vol. 11, No. 12 at 4-9. Thus, the flow field within asthenosphere of the southwest U.S. likely encounters both a sharp increase in the thickness of the cold lithosphere, as well as several "pockets" of unusually hot asthenosphere. Because the viscosity of mantle rocks is thought to vary strongly with temperature (*see* Kohlstedt, D.L., Evans, B. and Mackwell, S.J. (1995), "Strength of the Lithosphere: Constraints Imposed by Laboratory Experiments," JOURNAL OF GEOPHYSICAL RESEARCH, Vol. 100 at 17587-17602), the cold lithosphere and hot "pockets" can be thought of as high-viscosity and low-viscosity features, respectively.

Thus, the rapid asthenospheric shear flow that is present beneath the Basin and Range province is occurring in the presence of possibly large variations in lithospheric and asthenospheric viscosity. Upwelling produced by the interaction of the shear flow, low velocity "pockets" and lithospheric topography produce melting of the asthenosphere and the generation of basaltic magma. In this way, basaltic magma can be produced for long periods of time in the same geographic area. The primary control of the location of a basaltic field is therefore asthenospheric processes and not upper crustal structure or local stress fields.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 2.2.2.2.3.1 and related subsections, which indicate that DOE relies heavily on upper crustal structures and the local stress field to predict the location and frequency of future eruptions.

Supporting reasons are given in Section 5 above and may be summarized as follows: Although geophysical studies are mentioned in SAR Subsection 2.2.2.1.2 as a way to identify and characterize the orientation of faults in the subsurface, the license application lacks geophysical data to document models proposed by DOE that use upper crustal structure and the local stress field to explain the location of volcanoes in the Yucca Mountain area. Whether volcanoes are primarily controlled by upper crustal structure or mantle processes is a fundamental question, and DOE’s approach, which relies on upper crustal structures and local stress fields, is not supportable unless geophysical studies that detail the geometry of upper crustal structures, lithospheric thickness and basal topography, and circulation in the mantle are conducted to confirm or rule out the proposition, supported by the currently available data, that the primary control of the location of a basaltic field near Yucca Mountain is asthenospheric mantle processes.

(u) Overall TSPA Analysis

NEV-SAFETY-159 - PROPAGATION OF CONCEPTUAL AND PARAMETRIC UNCERTAINTIES THROUGH THE SAFETY ASSESSMENT

1. A statement of the contention itself

SAR Subsection 2.4.1.1 and similar subsections, which claim that the TSPA approach combines the underlying model abstractions in such a way that it incorporates the estimated ranges of uncertainty in the parameter distributions, model abstractions, and disruptive events and then propagates this uncertainty into estimates of the annual dose, fail to propagate a full range of uncertainties and doing so would require the performance of a substantial number of additional modeling cases.

2. A brief summary of the basis of the contention

The TSPA calculations are based on a small number of scenario classes distinguished into a somewhat larger number of modeling cases, but only limited account is taken of alternative ways of partitioning the calculations, selecting alternative models or selecting parameter value distributions, so limiting the range of uncertainty included in the results of the performance assessment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. 10 C.F.R. § 63.114(c) further requires that any performance assessment must consider alternative conceptual models of features and processes that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The TSPA is a central component of the performance assessment. It uses a predefined set of scenarios distinguished into a somewhat larger number of modeling cases as a basis for the assessment calculations. Within each modeling case, a particular set of model abstractions is used to propagate uncertainties in input parameter values into uncertainties in assessment results.

However, alternative possibilities exist for the identification of scenarios, the partitioning of those scenarios into modeling cases, the choice of model abstractions to represent those modeling cases, and the choice of parameter value distributions for use with those model abstractions. By carrying forward only a single set of choices at each of these stages, the range of uncertainty in the assessment is reduced.

Furthermore, because many of these choices will affect the overall distribution of results from all realizations in a scenario or modeling case, a full appreciation of the potential overall bias in the assessment can only be achieved by propagating the alternatives separately through the assessment and determining their overall effect on the compliance results set out in 10 C.F.R. § 63.303. That is to say, when evaluating compliance based upon the arithmetic mean or median of projected doses, it is not sufficient to examine the robustness of the mean or median against statistical uncertainties, but it is also necessary to examine the robustness of the mean and median against conceptual uncertainties (scenarios and modeling cases adopted, model abstractions used and shapes of parameter value distributions considered appropriate). Statistical convergence of results cannot address these issues.

In other contentions, particular instances of these various conceptual uncertainties are identified that have not been addressed by DOE. DOE has failed to comply with 10 C.F.R. § 63.114(c) because DOE has not recognized and considered these alternatives nor has DOE evaluated the effects that they have on the performance of the geological repository. As a result, DOE has also failed to comply with 10 C.F.R. § 63.114(b) because, without addressing these alternative models, the full implications of uncertainties and variabilities in parameter values cannot be evaluated.

In some instances, the likely implications of the conceptual uncertainties for performance assessment results can be assessed qualitatively or semi-quantitatively by inspection. However, the TSPA is a complex non-linear model, and changes in the conceptual basis of the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case. Therefore, the non-compliances with 10 C.F.R. §§ 63.114(b) and (c) can only resolved if DOE adopts a broader-based strategy to demonstrate that the full range of relevant calculations have been identified and propagated through the performance assessment, and the results have been displayed at a degree of disaggregation sufficient to permit the effects of different conceptualizations on the assessment results to be distinguished from the effects of parametric uncertainty.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The TSPA approach set out in SAR Subsection 2.4.1.1 and similar subsections fail to meet the requirements of 10 C.F.R. §§ 63.114(b) and (c) because examination of the TSPA shows that a full range of conceptual uncertainties has not been propagated. This non-compliance can only be resolved if DOE adopts a broader-based strategy to demonstrate that the full range of relevant calculations have been identified and propagated through the performance assessment, and the results have been displayed at a degree of disaggregation sufficient to permit the effects of different conceptualizations on the assessment results to be distinguished from the effects of parametric uncertainty. Implementation of this strategy would require the performance of a substantial number of additional modeling cases.

NEV-SAFETY-160 - PROBABILITY DENSITY FUNCTIONS USED IN THE TSPA

1. A statement of the contention itself

SAR Subsection 2.4 and similar subsections, which describe and rely upon results from the TSPA, fail to recognize that the probability density functions used in the modeling rely on arbitrary and implicit assumptions, and hence do not fully account for uncertainties and variabilities in parameter values and do not provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment.

2. A brief summary of the basis for the contention

The TSPA is a complex non-linear model that samples several hundred input parameter values from probability density functions with a wide range of different shapes. The shapes of the probability density functions used have not been justified, are not well constrained by the available information, and involve additional, implicit judgments. The results obtained from the TSPA will have been substantially determined by the shapes of the distributions adopted, but sensitivities to the shapes of the distributions have not been systematically explored. This, in turn, means that a significant source of uncertainty in the assessment has not been quantified or reported.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of 10 C.F.R. § 63.113. 10 C.F.R. § 63.114(b) requires that any performance assessment must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

As described in SAR Subsection 2.4 at 2.4-1, the term "total system performance assessment" or "TSPA" refers to the model, analyses, and codes used to estimate overall performance. "TSPA model" refers to the computational tool (which is a suite of coupled software codes and associated pre- and post-processors), and associated input files, used to conduct the analyses needed to satisfy the performance objectives established in 10 C.F.R. § 63.113 and the three performance assessments required by 10 C.F.R. § 63.342. The TSPA model takes account of uncertainties in parameter values by sampling from probability density functions for the various parameters of the model. Results of the calculations are reported as time-dependent distributions of annual effective dose equivalent by realization and the compliance quantity adopted is the arithmetic mean or median of the dose estimates for all realizations at each time.

As explained in SAR Subsection 2.4 at 2.4-6:

> The TSPA separates quantitative uncertainty in model inputs into two categories: aleatory uncertainty and epistemic uncertainty. Aleatory uncertainty primarily refers to the inherent uncertainty regarding the timing and magnitude of future events that could affect the repository and the impact of these events on repository performance. Because aleatory uncertainty cannot be reduced by the acquisition of additional data or knowledge, this kind of uncertainty is also referred to as irreducible uncertainty. Examples of aleatory uncertainty considered in the TSPA include the time and amplitude of seismic ground motion events, the occurrence of igneous events, and the location and number of early failures of waste packages and drip shields due to undetected manufacturing or emplacement defects.
>
> The other important type of uncertainty is called epistemic uncertainty and stems from a lack of knowledge about a parameter or a probability distribution that is believed to be fixed (or deterministic). Sources of epistemic uncertainties include incomplete data, estimates based upon expert judgment, and measurement errors. Unlike aleatory uncertainty, epistemic uncertainty is potentially reducible with additional data and knowledge. In the TSPA model, epistemic quantities are generally inputs to specific submodels, with the submodels having been developed to use single values for these quantities. A particular epistemic quantity can be a parameter that characterizes a probability distribution (*e.g.*, the mean value of the fracture permeability distribution used to calculate drift seepage), a field of values selected from alternative sets (*e.g.,* flow field in the unsaturated zone), or a measured parameter that characterizes a physical-chemical process (*e.g.*, the temperature dependency of general corrosion of Alloy 22 (UNS N06022) or the unsaturated-zone fracture frequency).

The TSPA model was made available to the State of Nevada on an external hard drive. Serco Assurance Limited examined the model and identified all the sampled variables and compiled information on them ("TSPA Model Sampled Variables (12/01/2008), LSN# NEV000005505, 350 pages). That compilation demonstrates the wide variety of distribution types adopted. These include uniform, triangular, normal, truncated normal, truncated lognormal, discrete, beta, gamma, loguniform, and cumulative piecewise constant. The justification for selecting one distribution shape over another is not provided by DOE either in the LA or in the documentation incorporated within the TSPA model. For example, there seems to be no physical basis for sampling the concentration of embedded plutonium in waste-form colloids from a triangular distribution. In contrast, the TSPA samples the concentration of irreversibly attached plutonium on CSNF colloids from a uniform distribution and selects the forward rate constant for irreversible sorption of plutonium and americium on colloids from a loguniform distribution.

Many of the distributions are obviously determined by a lack of knowledge. For example, the TSPA selects the volume of nonlithophysal rock required to fill a drift from a uniform distribution on the range 30 to 120 $m^3 m^{-1}$. This is a distribution based on ignorance and reflects an apparent judgment that, given the minimum and maximum values, all intermediate values are equally probable (whether they are or not). Similarly, the TSPA takes the probability density of the residual yield threshold for C22 to be uniformly distributed over the range 90 to 105% of its yield strength, again presumably based on the view that in the absence of any additional information all values within the proposed range are equally probable.

Triangular distributions arise where a range and best estimate are available, *e.g.*, for the HLW glass surface area exposure factor the TSPA adopts a triangular distribution with the maximum probability density arising at the minimum value of the factor (in this case 4) and the probability density reaching zero at the maximum value of the factor (in this case 17). Presumably this means that if provided with the upper and lower bounds of a range, DOE would select a uniform distribution; whereas if DOE received the same upper and lower bounds together with a best estimate located half way between them, it would select a triangular distribution with its maximum at the best estimate decreasing to zero at the limits of the range. Note that, in this example, the best estimate could have been derived by a process of simple arithmetic averaging – it does not provide any additional information and may bear no particular relevance to the physical world the TSPA is modeling. Therefore, depending upon how the original information is presented, DOE may adopt two very different distributions for assessment purposes. Indeed, there are cases in which the TSPA adopts a triangular distribution for the logarithm of the quantity of interest rather than the quantity itself (*e.g.*, specific surface area of corroding CSNF) resulting in yet another type of distribution for the same level of available information (*i.e.*, range and best estimate).

Thus, irrespective of the merits or otherwise of the inputs used to derive the probability density functions adopted in the TSPA, the distributions are not strongly constrained by those inputs. Instead, DOE selects the actual shapes based on additional, implicit and arbitrary assumptions. This is of considerable importance because the TSPA is a highly non-linear model, so the results obtained will be determined by the shapes of the probability density functions used. For example, the C22 corrosion rate DOE selects will determine the time to package penetration and radionuclide release, so sampling from the probability density function will affect the timing of radionuclide releases. Hence, at any specific time, there will be contributions to the dose to the RMEI only for realizations in which the ratio of the thickness of C22 to the sampled corrosion rate is less than that time. Use of a uniform distribution of corrosion rates across a specified range will result in a greater likelihood of radionuclide releases at early times than a triangular distribution across that same range.

In summary, the LA does not justify the shapes of the probability density functions used in the TSPA, and those shapes are not well constrained by the available information. The results obtained from the TSPA will have been substantially determined by the shapes that DOE has adopted arbitrarily and largely as a substitute for the lack of actual information that DOE could have obtained. Furthermore, DOE does not systematically explore the sensitivity of its model to the shapes that it has arbitrarily chosen.

This, in turn, means that a significant source of uncertainty in the assessment has not been quantified and reported. This is not compliant with 10 C.F.R. § 63.114(b), which requires that any performance assessment used to demonstrate compliance with 10 C.F.R. § 63.113 must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. Also, because the response of the model is not linearly related to the input parameter values, this failure to have accounted for the uncertainty in parameter value distributions means that the results of the assessment are likely to be biased. The degree of such bias cannot be determined without running variant TSPA cases using alternative distributions.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 2.4 and similar subsections, which describe and rely upon results from the TSPA, because they fail to recognize that the probability density functions used in the modeling rely on arbitrary and implicit assumptions, and hence do not comply with 10 C.F.R. § 63.114(b), which requires that any performance assessment used to demonstrate compliance with 10 C.F.R. § 63.113 must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform.

Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

(v) Multiple Barriers

NEV-SAFETY-161 - CRITICAL ROLE OF DRIP SHIELD

1. A statement of the contention itself

The LA violates the requirements that there be "multiple barriers," because its safety depends dispositively upon a single element of the engineered barrier system – the drip shield.

2. A brief summary of the basis for the contention

The license application violates the requirement in 42 U.S.C. § 10141(b)(1)(B), and 10 C.F.R. §§ 63.113(a)-(d) and 63.115(a)-(c) that there be "multiple barriers" (so that the safety of the repository does not rest upon a single barrier), because if the drip shield is not fabricated, assembled, transported, or installed properly or fails to operate within a narrow set of tolerances contemplated in the license application, there is, by that fact alone, no "reasonable expectation that, for 10,000 years following disposal, the reasonably maximally exposed individual receives no more than an annual dose of 0.15 mSv (15 mrem) from releases from the undisturbed Yucca Mountain disposal system," as specified by 10 C.F.R. § 63.311, and required by that section and also Sections 63.113(b) and 63.303, or any lawful standard to be established under Section 63.341.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with both statute, 42 U.S.C. § 10141(b)(1)(B), and NRC regulations, 10 C.F.R. §§ 63.113(a)-(d) and 63.115(a)-(c), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply

with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.113(a) (part of Subpart E) requires that "[t]he geologic repository must include multiple barriers, consisting of both natural barriers and an engineered barrier system," and Section 63.113(b) requires that "[t]he engineered barrier system must be designed so that, working in combination with natural barriers, radiological exposures to the reasonably maximally exposed individual are within the limits specified at § 63.311 of subpart L of this part ...." 10 C.F.R. § 63.311 (part of Subpart L) requires DOE to show a "reasonable expectation that, for 10,000 years following disposal, the reasonably maximally exposed individual receives no more than an annual dose of 0.15 mSv (15 mrem) from releases from the undisturbed Yucca Mountain disposal system."

In Section 121 of the Nuclear Waste Policy Act, Congress also specified that the technical requirements and criteria for this repository "provide for the use of a system of multiple barriers in the design of the repository." 42 U.S.C. § 10141(b)(1)(B). *See also* 10 C.F.R. § 63.115 (setting forth requirements for the multiple barriers). This contention alleges non-compliance with both the statutory requirement of a multiple barrier system and the regulations the NRC has promulgated to implement it, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

An analysis of DOE's own documentation reveals that without the protection DOE claims to receive from the drip shield, the "reasonable expectation" is that, during the 10,000 years following disposal, the reasonably maximally exposed individual will receive a peak mean annual dose of about 1.5mSv (150 mrem), or ten times the regulatory standard set forth in 10 C.F.R. § 63.311. This analysis is based on a recalculation of DOE's Expected Annual Dose for the Drip Shield Early Failure Modeling Case (1/2008), LSN# DEN001579005, Fig. ES-46(a) at

FES-460, based on SAR Subsection 6.4.1.2, Eq.6.4-2 at 6.4-3 that indicates Fig. ES-46 is a dose calculation for 0.018 expected drip shield early failures. If it is assumed that all 11,200 waste packages (*see* LSN# DEN001593669 (06/2008), Tbl. 4-32 at 4-99), are unprotected by drip shields, DEN001579005, Fig. ES-46 can be rescaled to show the dose curve for failure of all the waste packages, since waste packages are assumed to quickly fail by localized corrosion in DOE's drip shield early failure case (*see* DEN001579005, ES9.2.2.1 at ES-41). The rescaled mean annual peak dose is about 1.5mSv (150 mrem).

Accordingly, instead of basing safety upon the assurance of "multiple barriers," the compliance of the repository with the safety standard is instead dependent on a single barrier system. There are a number of reasons why the drip shield may not be there: (a) the over $4 billion of titanium and palladium required for the drip shield cannot be procured; (b) the drip shield cannot be fabricated on the schedule necessary to install it; (c) the integrity of the drip shields cannot be sufficiently maintained in transportation; (d) the technology to construct them does not exist; (e) errors, cave-ins, or even rocks on the ground of the drifts prevent the nearly 11,500 pieces of the drip shield from interlocking flush; or (f) any of a number of technical problems prevent installation of all or any significant portion of the drip shields. If the drip shields are not in place for one or more of these problems, the failure of this single barrier will cause the total system to fail.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The License Application contains 3,579 references to the drip shield, many of which emphasize the ostensibly protective power of the drip shield and its importance to total system performance. *See, e.g.*, GI Subsections 1.1.3.1 1.1.3.2 and SAR Subsections 1.3.2.; 1.3.4; 2.1.1; 2.1.2; 2.1.3; 2.1.4; 2.2.1; 2.2.2; 2.3.4; 2.3.5; 2.3.6; 2.3.8, and their respective subsections.

Subsection 2.1 of the SAR declares that "[a] critical element for repository safety is a site and system that provide multiple barriers to the movement of water and radionuclides," and then asserts that the drip shield and other purported barriers meet this requirement, *see, e.g.*, SAR Subsections 2.1.1.2; 2.1.2; 2.1.2.1.2; 2.1.2.1.5; 2.1.2.2; 2.1.2.2.1; 2.1.2.2.2; 2.1.2.2.3; 2.1.2.2.4; 2.1.2.2.5; 2.1.2.2.6; 2.1.2.3.6; 2.1.3.2; 2.1.4, and related subsections, when, as explained above, they do not.

NEV-SAFETY-162 - DRIP SHIELD INSTALLATION SCHEDULE

1. A statement of the contention itself

From SAR Subsections 1.1.3.1 and 1.1.3.2, and related subsections, it is clear that DOE plans to install the drip shields about one-hundred years from now, after all of the wastes are emplaced in the tunnels and just prior to repository closure, but this cannot be justified as safe because if installation of the drip shields proves to be defective or impossible it will be too late to assure safety by alternative means.

2. A brief summary of the basis for the contention

DOE plans to install the drip shields about one-hundred years from now, after all of the wastes are emplaced in the tunnels and just prior to repository closure, but this cannot be justified as safe because if installation of the drip shields proves to be defective or impossible it will be too late to assure safety by alternative methods short of retrieving the wastes from the tunnels. However, there are no retrieval plans, or even retrieval details, and therefore there is no reasonable assurance that retrieval will be feasible as a fall-back to protect safety.

3. A demonstration that the contention is within the scope of the hearing

The Commission's regulations in 10 C.F.R. § 63.31(a)(2), and section II, paragraph 1 of the notice of hearing, both provide that this issue is within the scope of the hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) provides that, before issuance of a construction authorization, NRC must find reasonable assurance that the materials can be disposed of without unreasonable risk to the public health and safety. Moreover, under 10 C.F.R. § 63.113(b), NRC must also find that the engineered barrier system, working with the natural barriers, works to comply with EPA individual dose standards. This contention challenges compliance with these provisions, as well

as the "multiple barrier" requirement in section 121(b)(1)(B) of the NWPA, and therefore raises a material issue.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

DOE plans to install the drip shields about one-hundred years from now, after all of the wastes are emplaced in the tunnels and just prior to repository closure, but this cannot be justified as safe because if installation of the drip shields proves to be defective or impossible it will obviously be too late to assure safety by alternative methods short of retrieving the wastes from the tunnels. This concern about installation proving to be defective or impossible is not speculative but well founded, as paragraph 5 of contention NEV-SAFETY-130 demonstrates. Moreover, as paragraph 5 of contention NEV-SAFETY-161 demonstrates, proper installation of the drip shields is vital to safety.

Subsection 1.11 of the SAR at 1.11-1 through 1.11-16 describes DOE's proposed retrieval plan in a scant sixteen pages, and provides only limited information about basic retrieval concepts. It promises that "[s]pecific plans for retrieval will be developed and defined in detail should the need for retrieval be identified." *Id*. at 1.11-1 and 1.11-2. Thus, the absence of any plans or detailed information about retrieval makes it impossible now to find reasonable assurance that retrieval will be a feasible protective option if drip shields are not installed or are installed with major defects (such as spaces between shields allowing water to reach the waste packages). *See also* NEV-SAFETY-134 and NEV-SAFETY-168.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 1.1.3.1 and 1.1.3.2, and related subsections, from which it is clear that that DOE plans to install the drip shields about one-hundred years from now, after all of the wastes are emplaced in the tunnels and just prior to repository closure, and therefore raises a material issue.

(w) Criticality

NEV-SAFETY-163 - SCREENING OF NEAR-FIELD CRITICALITY

1. A statement of the contention itself

SAR Subsection 2.2.1.4.1.3.3 and similar subsections estimate an unreasonably low probability of the occurrence of advective seepage onto a waste package for nominal scenarios, which leads to near-field criticality being inappropriately screened from consideration.

2. A brief summary of the basis of the contention

In the nominal scenarios, localized corrosion initiated by seepage flow through improperly emplaced drip shields is acknowledged by DOE in SAR Subsection 2.2.1.4.1.3.3 to have the potential to cause an advective flow of water through a waste package that could result in a release of fissile material and give rise to near-field criticality within the first 10,000 years, but this process is screened from further consideration by use of an estimate of the frequency of occurrence of improperly placed drip shields that is unreasonably low and is based on erroneous application of a human reliability analysis.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.113 (part of Subpart E) requires that compliance with that paragraph must be demonstrated through a performance assessment that meets the requirements specified at 10 C.F.R. §§ 63.114, 63.303, 63.305, 63.312 and 63.342 (the latter four are part of Subpart L). 10 C.F.R. § 63.342 (part of Subpart L) sets limits on performance assessments by excluding some features, events and processes from consideration that are estimated to have less than one chance in 10,000 of occurring within 10,000 years of disposal and provides that performance assessments need not evaluate the impacts resulting from any features, events and processes with a higher chance of occurrence if the results of the performance assessments would not be changed significantly in the initial 10,000-year period after disposal. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 2.3.6.8.4.3.2.4 assesses the frequency for occurrence that a drip shield is improperly installed in the repository leaving a gap between adjacent drip shields. This frequency directly affects the safety assessment, as it results in water penetration and the early failure of an underlying waste package. The probabilities used in the analysis are based upon whether or not the operator will notice and respond to the error, and whether a checker will recognize the error and respond. Thus, all these probabilities are estimates of human reliability. The data used are set out in SAR Table 2.3.6-22 and two DOE reference documents: "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications Final Report," NUREG/CR1278 (1983), LSN# DN2002064865, all; and "Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities (U)" (02/28/1994), LSN# DEN001584210, all.

Neither of these DOE reference documents is relevant to the specific conditions that will apply in the subsurface at Yucca Mountain. Furthermore, the human error probabilities (HEP) used do not relate closely to the activities involved. For example, inspection of the connection between two drip shields by video camera observation is described as, "Error of commission of check reading analog meter with difficult to *see* limit marks, such as scribe lines." SAR Table 2.3.6-22 at 2.3.6-143. Also, no attempt has been made to adapt the data to the specific conditions at Yucca Mountain. Specifically, DOE reference document "Analysis of Mechanisms for Early Waste Package/Drip Shield Failure" (06/29/2007), LSN# DN2002451287, Section 4 at 4-2 states:

> The fact that the HEP values given in Table 4-1 correspond to nominal probabilities should be emphasized. No performance-shaping factors are used for this evaluation. In general, performance-shaping factors are utilized to alter the nominal HEP in order to account for the effects of factors such as equipment design, operator skills, and psychological and physiological stresses. Because the procedures and equipment that will be put into service to perform the fabrication and handling of the waste package outer corrosion barrier and the drip shield have not yet been precisely identified, use of performance shaping factors is inappropriate.

However, it would be more appropriate to state that because the procedures and equipment that will be put into service have not been specified, no reliance can be placed on generic factors derived for other purposes that have not been demonstrated to be relevant to the proposed application. Furthermore, as these generic factors are used multiplicatively, the errors arising from their use in this application will be compounded. Thus, the overall error in the assessed frequency of improper drip shield installation could be several orders of magnitude.

In addition, the argument is that four independent failures have to occur in order to result in an emplacement error. These are: (a) the operator fails to interlock the drip shield properly; (b) the failure is not detected by a remote camera inspection; (c) the operator fails to respond to a process malfunction annunciator; and (d) the checker fails to detect that the operator has not responded to a process function annunciator. These four probabilities are treated as independent events. Based on this analysis, the overall frequency for occurrence that a drip shield is improperly installed is estimated as 4.36×10^{-9}.

Although the mathematics of this analysis is straightforward, the underlying principles are suspect and the result is of little value. Common sense would question whether a process that relies entirely upon human skill and judgment (note that all four steps (a) through (d) require either human actions or human responses) can achieve a failure rate of below one in one hundred million.

Some key factors that are likely to make the approach erroneous are listed below.

1) It assumes that the process malfunction annunciator is operating. If it is not operating then the operator cannot respond to it and the checker cannot recognize that failure to respond.

2) It assumes that remote camera and annunciator operations are maintained throughout the repository filling period. However, with a routine connection operation, there may be a tendency to switch off or ignore such QC measures, or to continue operations when one of the systems is out of operation.

3) On a related point, it assumes that remote camera inspection and annunciator give perfect information; if the camera provides ambiguous information then it may cease to be relied upon. Similarly, if the annunciator generates a significant rate of warnings when the interlocks between drip shields prove to be satisfactory, it may be ignored. Indeed, the very fact that both camera inspection and malfunction annunciator are provided may mean that one of these two sources of information is ignored (*e.g.*, there is no perceived need to look at the camera images because the annunciator will provide an alert as to there being a failure of emplacement).

More generally, where acts of human volition are involved, it is widely recognized that accidents or failures of performance tend to occur when rules are violated. *See* Breakwell, G.M. (2007), "The Psychology of Risk" (Cambridge University Press, Cambridge, UK) at 173-195 and in particular, conclusions at 194). In the case of drip shield emplacement, there will be little immediate evidence of a failure in emplacement (except that available to the operator and checker), nor is there necessarily any deleterious consequence for the operator or checker. Therefore, a degree of sloppiness is likely to enter into this repetitious procedure (*e.g.*, emplacements occur, in violation of rules, when the checker is not present, or camera images are not inspected by the operator, who relies on the annunciator for information as to whether there is a problem).

Finally, it is noted that it is not clear that the system fails to safety. If the process malfunction annunciator does not provide a signal, this could either be because the emplacement is satisfactory or because the malfunction annunciator is not operating.

Overall, because the procedures and equipment that will be put into service to ensure accurate drip shield emplacement have not been specified, and because various key factors are neglected in the analysis, no reliance can be placed on the overall frequency derived by DOE for the occurrence that a drip shield is improperly installed. Furthermore, by considering the largest possible number of events and treating them as independent, DOE has systematically underestimated this frequency. The degree of underestimation cannot be determined on the basis of the information available, but it is likely to be several orders of magnitude.

SAR Subsection 2.2.2.3.3 identifies approximately 11,600 drip shields. With DOE's estimate of the overall frequency for occurrence that a drip shield is improperly installed of 4.36×10^{-9}, this gives the probability of one or more drip shields being improperly installed as 5.06×10^{-5}, which is less than one in ten thousand. However, the overall frequency for occurrence that a drip shield is improperly installed would have to be increased only to 9×10^{-9} to give an overall frequency for occurrence that a drip shield is improperly installed of greater than one in 10,000.

From the argument above, the frequency estimated by DOE is likely to be several orders of magnitude too low, so the frequency of occurrence of improperly installed drip shields is also likely to be several orders of magnitude larger than the screening criterion of one in 10,000. Furthermore, DOE assumes that in the drip shield early failure modeling case, complete failure of the drip shield occurs (*see* SAR Subsection 2.4.1.2.2). Also, as a bounding assumption, the waste package under an early failed drip shield is assumed to experience localized corrosion over its entire surface as soon as seepage contacts the waste package, since the area of the Alloy 22 waste package that is contacted by seepage is potentially subject to localized corrosion (*see* SAR Subsection 2.3.6.4). Thus, early entry of water into waste packages and rapid leaching of fissile materials to the near field can occur, potentially resulting in criticality in the first 10,000 years. Because this scenario is screened on probability grounds, DOE presents no arguments concerning either the likelihood of criticality resulting from such leaching or its impacts on the performance assessments.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

In SAR Subsection 2.2.1.4.1.3.3 an unreasonably low probability of the occurrence of advective seepage onto a waste package is estimated for nominal scenarios. This arises because DOE has systematically underestimated the overall frequency for the occurrence that a drip shield is improperly installed. Because DOE assumes that, in the drip shield early failure modeling case, complete failure of the drip shield occurs (*see* SAR Subsection 2.4.1.2.2) and that the waste package under an early failed drip shield experiences localized corrosion over its entire surface as soon as seepage contacts the waste package, it follows that the occurrence that a drip shield is improperly installed leads to early entry of water into a waste package and the potential for rapid leaching of fissile materials to the near field. Because this scenario is screened by DOE on probability grounds, no arguments have been presented by DOE concerning either the likelihood of criticality resulting from such leaching or its impacts on the performance assessments. Thus, DOE is in conflict with 10 C.F.R. § 63.342, as near field criticality cannot be screened on probability grounds and no arguments have been presented evaluating its impacts on performance assessments.

(x) Expert Elicitation

NEV-SAFETY-164 - AGGREGATION OF PROBABILITY DISTRIBUTIONS

1. A statement of the contention itself

The process described for the conduct of expert elicitation in SAR Subsections 5.4.1 for probabilistic volcanic hazard analysis (PVHA), 5.4.2 for probabilistic seismic hazard analysis (PSHA), and 5.4.3 for saturated zone flow and transport (SZFT) and similar subsections was realized by using only one method for aggregating probability distributions from groups of experts, so failing to demonstrate the results of other equally valid aggregations that could have been less favorable to the safety case.

2. A brief summary of the basis for the contention

The method of aggregating probability distributions elicited from individual experts represents only the spread of opinion of the experts, but represents neither the central tendency of the experts' probability distributions nor a consensus distribution that could have been generated by the experts interacting as a group.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart

E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(c) requires consideration to be given to alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and to evaluate the effects that alternative conceptual models have on the performance of the geologic repository. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Expert elicitation has been used by DOE in attempting to justify the safety case at Yucca Mountain, and this contention questions the adequacy of the aggregation step in the elicitation methodology used.

The methodology described in SAR Section 5.4 is based on the nine-step expert elicitation procedure described in NUREG-1563 (*see* Kotra, *et al.* (1996), "Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program," LSN# NRC000011836), which does not provide guidelines for how individually assessed probability distributions should be aggregated, in step 8, across experts. Therefore alternative aggregation approaches should have been reported because each might have a different effect on the overall safety case for Yucca Mountain. Specifically, the alternative aggregation approaches constitute alternative conceptual models of the aggregation process that should have been addressed and propagated through the assessment.

To show that the different methods of aggregation yield different results, an example of application of the three alternative methods is given below. First, the following figure, which is

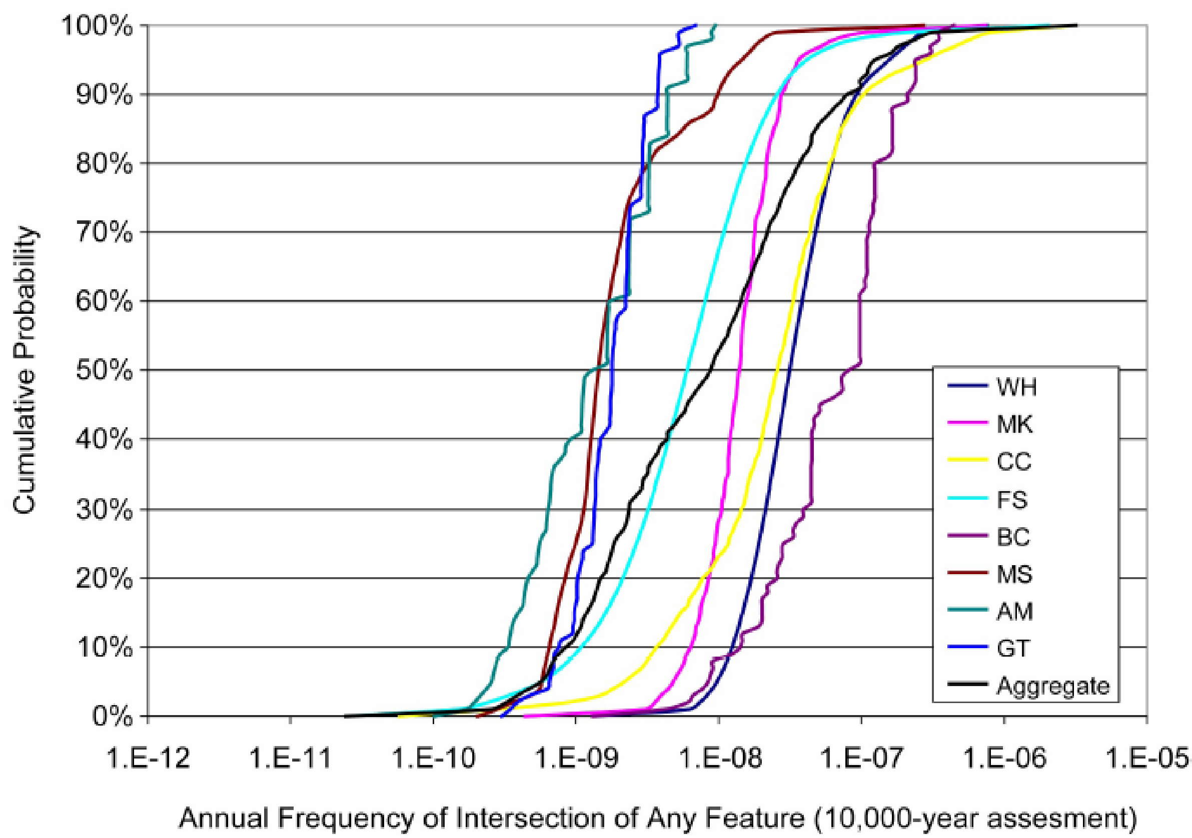

Figure 4.2-2. Annual Frequency of Intersection of Any Feature with the Repository Footprint: Aggregate and Individual Cumulative Probability Results for the 10,000-Year Assessment

taken from PVHA-U at 4-115, shows cumulative probability distributions elicited from eight experts along with an aggregate distribution. The latter was calculated, using equal weights for the experts, by averaging vertically, i.e., for each value on the horizontal axis, the values vertically above were averaged. This is "probability averaging," and the resulting aggregate distribution represents the spread of opinion among the eight experts. It is shown by the black line, which cuts across the other eight cumulative distributions, so the variance is larger than any of the individual curves. By necessity, this cumulative distribution has to encompass the entire range of each individual distribution, from the very lowest annual frequency given by any expert to the very highest.

A second method is to average in the horizontal direction. In this case, a value of cumulative probability, shown on the left vertical axis is chosen, and the eight values horizontally to the right are averaged. This is annual-frequency averaging, and the resulting aggregate distribution represents the central tendency of the eight individual distributions. It would appear as an S-shaped curve roughly in the middle of the eight distributions with a slope that is, necessarily, an average of the others, so, unlike the aggregate from probability averaging, it would be about the same steepness as the eight.

A third alternative is a consensus distribution. This would be created by the eight experts interacting at workshops; no individual assessments would be carried out. The result would be only one distribution, and it would represent the combined experience of the eight experts, after thoroughly considering all available data, building a consensus model accommodating all their concerns, agreeing assumptions while leaving other factors to vary, considering alternative scenarios that could result in low or high values of the uncertain quantity, and eventually constructing a consensus distribution, conditional on their assumptions. An experimental test of this group-centric approach was reported in Phillips, L.D., "Group elicitation of probability distributions: Are many heads better than one?" (1999) (LSN# NEV000005089) in J. Shanteau, B. Mellors & D. Schum (Eds.), *Decision Science and Technology: Reflections on the Contributions of Ward Edwards*, Norwell, MA: Kluwer Academic Publishers (1999) at 313-330.

The task of the expert group in that experiment was to construct a consensus probability distribution about the corrosion rate of mild steel used in canisters holding radioactive waste buried in back-filled rock caverns deep underground. Each expert assessed his own individual cumulative probability distribution at early, middle and late stages of a structured, facilitated one-day discussion about the corrosion rate, and a consensus distribution was elicited just before the last individual assessments. Two results from that experiment are relevant here. First, the variances of the individually assessed probability distributions increased throughout the day; clearly, each expert's initial distribution was anchored on his own experience and knowledge, but as information was exchanged, each expert's uncertainty increased. Second, the variance of the corrosion-rate average (central tendency) was the smallest, the probability average (spread of opinion) the greatest, with the consensus distribution's variance between those two extremes. The differences in variances were not small; for two different groups of experts working on two different days, both showed the variance of the probability average distribution to be about twice that of the corrosion rate average (on a log scale). But, for one group, the consensus distribution's variance was more similar to the probability average, whereas for the other group it was closer to, but still less than, the corrosion rate average.

The point here is that all three types of distributions can give different results, and the failure to report all three in the LA casts doubt on the safety case, which is based on only the probability average distributions.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the adequacy of relying on only the single aggregate distribution reported for every expert elicitation, for that distribution has to cover the entire range of all the experts' distributions, so it is easily affected by a single outlier, giving undue emphasis to either a pessimistic or optimistic value of the relevant uncertain quantity. It is not sufficient to justify this approach on the grounds that by including the most pessimistic values of an uncertain quantity it errs in the conservative direction, for it also includes the most optimistic ones. The experiment reported here suggests that the consensus distribution would be more likely to represent a balance between these extremes, though more research is needed to provide solid empirical evidence for this assertion. There certainly is no empirical evidence at all to justify the averaging approach taken in the LA.

Overall, the approach adopted is non-compliant with 10 C.F.R. § 63.114(c), which requires consideration to be given to alternative conceptual models of features and processes that are consistent with available data and current scientific understanding, and to evaluate the effects that alternative conceptual models have on the performance of the geologic repository. Specifically, it is contended that alternative conceptual models of aggregation should have been considered, since they can lead to alternative conceptualizations of the processes for which the elicitations were undertaken. Furthermore, the use of alternative approaches to aggregation would have led to different parameter value distributions. Thus, the failure to consider these alternative models is also non-compliant with 10 C.F.R. § 63.114(b), which requires that any performance assessment used to demonstrate compliance with Section 63.113 must account for uncertainties and variabilities in parameter values and provide for the technical basis for parameter ranges, probability distributions, or bounding values used in the performance assessment. Use of a single, disputed method of aggregation is not adequate to provide such a technical basis.

Because the TSPA is a complex non-linear model, and changes in the approach adopted are likely to result in changes in the results obtained that vary both as a function of time post-closure and from realization to realization within a modeling case, a determination whether acceptance of this contention would necessarily lead to calculated doses in excess of EPA's dose

standards would require DOE to perform a substantial number of additional modeling cases that are not included in the LA and that are beyond the practical ability of anyone else to perform. Moreover, there are more than 100 Nevada TSPA contentions with characteristics like this one. These relate to a total of 19 different broad aspects of the TSPA. Therefore, there are many thousands of possible changes that would need to be made to DOE's TSPA approach to include the effects of accepting this one contention along with all possible combinations of Nevada's other contentions relating to different aspects of the TSPA, even if all contentions relating to each broad aspect of the TSPA were considered together in defining the variant cases. This vastly increases the burden and complexity of showing the dose effects of acceptance of Nevada's contentions.

NEV-SAFETY-165 - SATURATED ZONE EXPERT ELICITATION

1. A statement of the contention itself

SAR Section 5, Subsections 5.1, 5.4, 5.4.3, and similar subsections, and QARD 2.2.9 and 2.2.13.B.7, and similar subsections, which describe DOE's conduct of an expert elicitation relating to saturated zone flow and transport (SZEE) that is directly relied upon by DOE in its License Application (as well as the expert elicitation itself, DEN000672365), disclose a methodology so contrary to that which is required and that which DOE committed to employ as to render the SZEE inadequate and unusable in support of DOE's License Application.

2. A brief summary of the basis for the contention

DOE asserts in SAR Subsection 5.4 that its subsequent Subsection 5.4.3 regarding the SZEE complies with the requirements of 10 C.F.R. § 63.21(c)(19) and the applicable portions of NUREG-1804 for the conduct of expert elicitations to be relied upon in the LA; however, DOE admits in SAR Subsection 5.4 that "the process used to conduct an expert elicitation can have a significant effect on the results of the elicitation," and in that regard DOE's procedure for the conduct of the SZEE does not meet the requirements of 10 C.F.R. § 63.21(c)(19) or the guidance of NUREG-1804, and contradicts both the letter and the spirit of those references by employing processes for the selection of participating experts, their preparation and training, and the elicitation of their opinions, which are calculated to be biased and to result in an outcome predetermined by DOE, rather than an independent objective assessment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.21(c)(19) requires DOE to provide a detailed description of its implementation of expert elicitation, on any occasion in which DOE elects to utilize that methodology in support of its LA. Pursuant to 10 C.F.R. §§ 63.31(a)(1) and (2), the NRC will not authorize construction of a geologic repository operations area at Yucca Mountain unless it determines, among other things, that there is a reasonable expectation that radioactive materials described in the application can be received and possessed without unreasonable risk to the health and safety of the public. Where, as here, that determination is directly dependent upon the results of its SZEE, DOE's LA should be denied if its utilization of expert elicitation is flawed and inadequate.

The detailed requirements for an appropriate expert elicitation are set out by NRC in NUREG-1563; and its specific expectations for compliance in any instance where DOE elects to rely on expert elicitation are set out in the acceptance criteria of NUREG-1804. While DOE claims to follow the guidance of NUREG-1563 (LSN# DN2002065379) in satisfying the requirements of 10 C.F.R. § 63.21(c)(19), DOE does not do so. DOE asserts in QARD 2.2.9 and 2.2.13.B.7 that its own expert elicitations "shall be conducted in accordance with NUREG-1563, Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program (Nov. 1996) with a single exception," but DOE fails to do so in its employment of the SZEE, details of which are explained by DOE at SAR Subsection 5.4.3. This contention alleges non-compliance with these regulatory provisions (and DOE's own commitments) and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The point of a properly conducted expert elicitation is not to undertake new experiments or new site characterization; rather, it is to present evenhandedly selected existing data (chosen by independent, unbiased technical experts) to a panel of world-class experts in the particular field in order to secure their (again, independent and unbiased) opinions. By this approach the quality and relevance of the available data are appropriately weighed and their value is enhanced by being informed by the broader knowledge base of the experts involved in the process. However, in the SZEE, those who conducted the event and those who selected the experts, selected the data to be given to the expert panel, conducted the elicitation of the subject-matter experts' opinions, and prepared the final report resulting from the elicitation were overwhelmingly tied to DOE or its contractors. This is a recipe for an improperly conducted elicitation and an unreliable outcome. In DOE's conduct of its SZEE, instead of receiving **independent opinions** of subject-matter experts, with documentation of the rationale for any revisions made in those experts' opinions, DOE instead selected subject-matter experts by a biased group, trained and indoctrinated them by a biased group, and elicited their expert opinions only **after** numerous workshops and field trips (focused by biased leaders) were conducted for the specific purpose of testing, challenging, and revising those opinions, all implemented by a biased team.

DOE committed in SAR Subsection 5.4 and in QARD 2.2.9 and 2.2.13.B.7 to strictly embrace the guidance contained in NRC's NUREG-1563 as its methodology in meeting the requisites of 10 C.F.R. § 63.21(c)(19) for the use of expert elicitation in support of the LA. In the same two references, DOE committed to explain the justification for any instance in which it departed from the guidance of NUREG-1563. DOE neither followed the guidance of NUREG-

1563, nor did it explain the rationale for its departures from doing so. In embracing NUREG-1563, DOE was required to do both: the primary components of NRC's review of DOE's expert elicitation compliance are contained at NUREG-1804 Section 2.5.4.1(2) (providing that the Staff will evaluate the extent to which the guidance in NUREG-1563 was used by DOE to perform expert elicitations) and Section 2.5.4.1(9) (the Staff will verify that DOE provided an adequate explanation for any variance from NUREG-1563 guidance).

DOE asserts in QARD 2.2.13.B.7 that there is only a single exception to its otherwise complete commitment to the procedures set out in NUREG-1563. Specifically, the exception relates to "documenting the rationale for any revisions to elicited evaluations after the experts receive feedback on their initial evaluations." True to its word, DOE **did** omit in its SZEE documentation of the experts' rationale for revising their elicitations after receiving feedback. This is a very important omission and departure from NUREG-1563 in itself, since it is calculated to prevent exposing the degree to which the DOE process (aimed at pressuring the subject-matter experts into conformity with DOE's views) was successful or not. The point here is that DOE promised in SAR Subsection 5.4 to explain "any variance between the Staff guidance in NUREG-1563 and the DOE conduct of expert elicitations," and it did not do so. DOE does not attempt to give a rationale for its decision to exclude any explanation of the reasons why experts changed their opinions after receiving DOE input on their initial decisions. Rather, DOE simply states "OCRWM does not require documentation of the rationale for revisions to an expert's initial assessment." *See* QARD (LSN# DEN001574022) at 36. That is not a rationale; it is simply a statement of the non-conforming DOE practice, which DOE does not attempt to explain, but whose calculated effect is obvious.

The second particular in which DOE neither follows the procedures set out in NUREG-1563, nor makes any effort to explain why not, relates to disclosure of conflicts of interest on the part of subject-matter experts – again, a critical determinant of their likelihood to give opinions satisfactory to DOE, rather than to speak with independence. NUREG-1563 Section 2.5.4.2(2)(e) requires that the NRC Staff verify that DOE's expert selection criteria comply with the requirement that prospective experts must be "willing to publicly disclose potential conflicts of interest." Contrary to this provision, DOE provides in its SZEE methodology the simple statement that "the selection criteria **did not include** a criterion for willingness to publicly disclose potential conflicts of interest, as recommended in NUREG-1563." Not only did DOE's criteria for selection of the subject-matter experts **not** preclude conflicts of interest, it literally **invited** them: "Individuals who have a major role in the Yucca Mountain site characterization project may be included on the expert panel; however, such experience is **not a requirement** for participation." SZEE 2-6. Moreover, when conflict information was discovered, it was not disclosed in the SZEE, but squirreled away in unpublished files – "information on potential sources of conflict of interest was provided by each expert and documented in the SZEE administrative files." SZEE 2-7.

DOE's complete departure from two critical requisites of the methodology prescribed by NRC, and allegedly embraced by DOE, is more than a technical violation. Rather, both of those departures are symptomatic of an overall expert elicitation methodology employed by DOE which runs contrary to the letter and the spirit of NUREG-1563 in a way that permits DOE to improperly secure the desired result of its expert elicitation through the improper selection and training of the experts and the improper elicitation of their heavily pressured and frequently revised opinions.

NRC's NUREG-1563 discusses the types of experts who must be assembled for the conduct of a credible expert elicitation. According to NRC, an unbiased panel of "normative" experts must select a group of "equally unbiased" world renowned "subject-matter experts," provide them with data (supplied by equally unbiased technical experts) concerning the issues in question, and then free them to analyze the data and formulate conclusions and opinions. Only after each of the subject-matter experts reports his or her opinion, the entire group of experts may be brought together in an effort to see if a consensus or common ground can be reached on some or all of the issues under consideration. Among the significant criteria articulated by NRC for a credible elicitation:

- Because the "normative" experts who select the subject-matter experts may influence the outcome of the elicitation by the manner in which opinions are elicited, care should be taken in their selection to ensure they can perform in an objective and impartial manner (LSN# DN2002065379 at 15).
- The "generalist" technical experts, engaged to provide technical background data to the subject-matter experts for their analysis, must also be objective and impartial. *Id*.
- It cannot be emphasized enough that, because of the reviewer's potential need to examine an individual expert's judgments and reasoning bases, the professional judgment of each subject-matter expert must be explicitly documented (subsequently, an effort may be made to aggregate the judgments of the various experts, but it is essential that the individual experts' initial opinions must be preserved). The documentation should clearly distinguish between the opinions provided by each subject-matter expert and any subsequent processing of that information or aggregation of the judgments of different experts. *Id*. at 18.
- The NRC believes that even the effective implementation of a proper elicitation process cannot guarantee acceptance of the technical conclusions; however, the use of a flawed process or improper implementation of a good process cannot help but cast serious doubt on the quality of the conclusions. One of the stated purposes of NUREG-1563 is to describe **acceptable** procedures for conducting expert elicitation when formally elicited judgments are used to support demonstration of compliance with NRC's geologic repository disposal regulations. *Id*. at 4.

- When expert judgments are used to support a demonstration of compliance, sufficient documentation should exist to allow external examination of why the judgments were used instead of obtaining objective information. *Id*. at 19. (When, as here, some ten years has expired between the time of the elicitation and its utilization in direct support of the LA, with DOE expending a half billion dollars a year on continued analysis of YMP site characteristics, it raises the question whether this aged information has any remaining viability, and why in the ensuing decade, DOE has not filled any void in its knowledge of saturated zone flow and transport. Indeed, the purposes for the conduct of the SZEE more than ten years ago contradict the proposition that it be used in support of DOE's current LA. The goal of the SZEE when conducted was "to support the TSPA-VA (a much earlier version of DOE's TSPA) by providing an expression of uncertainties regarding key issues for the saturated zone." This was done so that "in addition to providing inputs to the TSPA-VA, the results of the study can also provide a focus for subsequent data collection activities." DOE's continued reliance on the SZEE as direct LA input a decade later belies its stated purposes.)
- NUREG-1563 contemplates that the same criteria should be applied in the selection of generalist and normative experts as are employed with respect to subject-matter experts and states "this is particularly true as it relates to the criterion concerning the appearance of bias or conflict of interest owing to the influence the generalist and normative expert can have on the outcome of any potential elicitation. *Id*. at 23.
- NRC recognized in NUREG-1563 that the opinions of the subject-matter experts may be dictated by the data which they are provided upon which to base their opinions: "The judgments of the subject-matter experts may be influenced by the type of information they receive, and the manner in which that information is presented. . . . Biasing may be introduced at this very influential point, and credibility of the elicitation could be reduced if a suitably broad range of information on a particular issue is not made available. *Id*. at 26.
- Finally, "the Staff cannot predict what weight, if any, the Licensing Board would attribute to expert opinion derived from an expert elicitation." *Id*. at 4.

Contrary to the entire philosophy thus articulated in NUREG-1563, and its own commitment to follow that guidance, DOE created a Methodology Development Team (responsible to carry out the project and select subject-matter experts) comprised of 9 persons, 8 of whom were DOE contractors; in selecting the technical specialists (whose assignment was to provide the subject-matter experts with documentation and specialized data and training through workshops and field trips), DOE chose 17 out of 17 technical experts for Workshop I of the SZEE from the ranks of DOE contractors, and 10 experts for Workshop II from DOE contractors, as well as 2 from the NRC and one from EPRI (a nuclear power advocate), out of a total of 15 members (LSN# DEN000672365 at 1-6, 1-7).

In a gross departure from NUREG-1563 methodology, the independent opinions of the experts were **not** elicited prior to their being "trained" and manipulated through a series of workshops and field trips. Only after tentative views had been disclosed and made the subject of debate, revision, challenge, revision, attack, and revision, were the "independent" elicitations finally conducted. Given the overwhelming DOE/contractor composition of the Methodology Development Team and the technical specialist group, this incremental methodology was calculated to have the effect of revising and orchestrating the "independent" thinking of the subject-matter experts. This is **precisely** the lack of objectivity forbidden by the most basic tenets of NUREG-1563. The outcome of the SZEE was inalterably tainted by the composition of the teams who selected and trained the subject-matter experts, without any need for any bias on the part of those individuals themselves. However, 60 percent of the subject-matter expert panel was composed of (1) the senior advisory scientist to the chemical and science technology division of Los Alamos National Laboratory (DOE contractor), (2) a senior staff scientist with Lawrence Berkeley National Laboratory (DOE contractor), and (3) a scientist with "extensive consulting experience with government and industry" dealing particularly with problems of radioactive waste disposal, including issues at Hanford and WIPP, both DOE facilities.

The saturated zone flow expert elicitation, as conducted by DOE, is totally inadequate and should not be accepted in support of the LA due to its stunning departures from the principles of objectivity and independence with respect to (1) the selection of the Methodology

Development Team members, (2) the selection of technical specialist experts, (3) the selection of subject-matter experts, and (4) the conduct of the elicitation itself, with multiple preliminary phases in which the actual independent opinions of the subject-matter experts were disregarded until **after** they had been massaged and revised multiple times through workshops and field trips conducted by an overwhelmingly DOE-biased team, until those opinions were deemed acceptable fodder for elicitation. The use in the LA of biased opinion, shaped by a flawed and biased selection, education, and elicitation process creates the risk of introducing error into the LA and its analyses which could lead to adverse health and safety consequences for workers and the public.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 5, 5.1, 5.4, 5.4.3, and similar subsections, and QARD 2.2.9, 2.2.13.B.7, and similar subsections, which describe DOE's conduct of an expert elicitation relating to SZEE that is directly relied upon in its License Application, because they disclose a methodology so contrary to that which is required and that which DOE committed to employ, as to render the SZEE inadequate and unusable in support of DOE's License Application.

NEV-SAFETY-166 - PROBABILISTIC SEISMIC HAZARD ANALYSIS EXPERT ELICITATION

1. A statement of the contention itself

SAR Section 5, Subsections 5.4 and 5.4.2, and similar subsections, and QARD 2.2.9, 2.2.13.B.7, and similar subsections, which describe DOE's conduct of an expert elicitation relating to Probabilistic Seismic Hazard Analysis (PSHA) that is directly relied upon in its License Application (as well as the expert elicitation itself, DEN000866273), disclose a methodology so contrary to that which is required and that which DOE committed to employ, as to render the PSHA inadequate and unusable in support of DOE's License Application.

2. A brief summary of the basis for the contention

DOE asserts in SAR Subsection 5.4 that its subsequent Subsection 5.4.2 regarding the PSHA complies with the requirements of 10 C.F.R. § 63.21(c)(19) and the applicable portions of NUREG-1804 for the conduct of expert elicitations to be relied upon in the LA; however, DOE admits in SAR Subsection 5.4 that "the process used to conduct an expert elicitation can have a significant effect on the results of the elicitation," and in that regard DOE's procedure for the conduct of the PSHA does not meet the requirements of 10 C.F.R. § 63.21(c)(19) or the guidance of NUREG-1804, and contradicts both the letter and the spirit of those references by employing processes for the selection of participating experts, their preparation and training, and the elicitation of their opinions, which are calculated to be biased and to result in an outcome predetermined by DOE, rather than an independent objective assessment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.21(c)(19) requires DOE to provide a detailed description of its implementation of expert elicitation, on any occasion in which DOE elects to utilize that methodology in support of its LA. Pursuant to 10 C.F.R. §§ 63.31(a)(1) and (2), the NRC will not authorize construction of a geologic repository operations area at Yucca Mountain unless it determines, among other things, that there is a reasonable expectation that radioactive materials described in the application can be received and possessed without unreasonable risk to the health and safety of the public. Where, as here, that determination by DOE is directly dependent upon the results of its PSHA, DOE's LA should be denied if its utilization of expert elicitation is flawed and inadequate.

The detailed requirements for an appropriate expert elicitation are set out by NRC in NUREG-1563 (LSN# DN2002065379); and its specific expectations for compliance in any instance where DOE elects to rely on expert elicitation are set out in the acceptance criteria of NUREG-1804. While DOE claims to follow the guidance of NUREG-1563 in satisfying the requirements of 10 C.F.R. § 63.21(c)(19), DOE does not do so. DOE asserts in QARD 2.2.9 and 2.2.13.B.7 that its own expert elicitations "shall be conducted in accordance with NUREG-1563, Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program (Nov. 1996) with a single exception," but DOE fails to do so in its implementation of the PSHA, details of which are explained by DOE at SAR Subsection 5.4.2. This contention alleges non-compliance with these regulatory provisions (and DOE's own commitments) and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The point of a properly conducted expert elicitation is not to undertake new experiments or new site characterization; rather, it is to present evenhandedly selected existing data (chosen by independent, unbiased technical experts) to a panel of world-class experts in the particular field in order to secure their (again, independent and unbiased) opinions. By this approach the quality and relevance of the available data are appropriately weighed and their value is enhanced by being informed by the broader knowledge base of the experts involved in the process. However, in the PSHA, those who conducted the PSHA and those who selected the experts, selected the data to be given to the expert panel, conducted the elicitation of the subject-matter experts' opinions, and prepared the final report resulting from the elicitation were overwhelmingly tied to DOE or its contractors. This is a recipe for an improperly conducted elicitation and an unreliable outcome. In DOE's conduct of its PSHA, instead of receiving **independent opinions** of subject-matter experts, with documentation of the rationale for any revisions made in those experts' opinions, DOE instead selected subject-matter experts by a biased group, trained and indoctrinated them by a biased group, and elicited their expert opinions only **after** numerous workshops and field trips (focused by biased leaders) were conducted for the specific purpose of testing, challenging, and revising those opinions, all implemented by a predominantly DOE-biased team.

DOE committed in SAR Subsection 5.4 and in QARD 2.2.9 and 2.2.13.B.7 to strictly embrace the guidance contained in NRC's NUREG-1563 as its methodology in meeting the requisites of 10 C.F.R. § 63.21(c)(19) for the use of expert elicitation in support of the LA. In the same two references, DOE committed to explain the justification for any instance in which it departed from the guidance of NUREG-1563. DOE neither followed the guidance of NUREG-

1563, nor did it explain the rationale for its departures from doing so. In embracing NUREG-1563, DOE was required to do both: the primary components of NRC's review of DOE's expert elicitation compliance are contained at NUREG-1804 Section 2.5.4.1(2) (providing that the Staff will evaluate the extent to which the guidance in NUREG-1563 was used by DOE to perform expert elicitations) and Section 2.5.4.1(9) (the Staff will verify that DOE provided an adequate explanation for any variance from NUREG-1563 guidance).

DOE asserts in QARD 2.2.13.B.7 that there is only a single exception to its otherwise complete commitment to the procedures set out in NUREG-1563. Specifically, the exception relates to "documenting the rationale for any revisions to elicited evaluations after the experts receive feedback on their initial evaluations." *See* QARD (LSN# DEN001574022) at 36. True to its word, DOE **did** omit in its PSHA documentation of the experts' rationale for revising their elicitations after receiving feedback. This is a very important omission and departure from NUREG-1563 in itself, since it is calculated to prevent exposing the degree to which the DOE process (aimed at pressuring the subject-matter experts into conformity with DOE's views) was successful or not. The point here is that DOE promised in SAR Subsection 5.4 to explain "any variance between the Staff guidance in NUREG-1563 and the DOE conduct of expert elicitations," and it did not do so. DOE does not attempt to give a rationale for its decision to exclude any explanation of the reasons why experts changed their opinions after receiving DOE input on their initial decisions. Rather, DOE simply states "OCRWM does not require documentation of the rationale for revisions to an expert's initial assessment." QARD 2.2.13.B.7. That is not a rationale; it is simply a statement of the non-conforming DOE practice, which DOE does not attempt to explain, but whose calculated effect is obvious.

The second particular in which DOE neither follows the procedures set out in NUREG-1563, nor makes any effort to explain why not, relates to disclosure of conflicts of interest on the part of subject-matter experts – again, a critical determinant of their likelihood to give opinions satisfactory to DOE, rather than to speak with independence. NUREG-1563 Section 2.5.4.2(2)(e) requires that the NRC Staff verify that DOE's expert selection criteria comply with the requirement that prospective experts must be "willing to publicly disclose potential conflicts of interest." Contrary to this provision, DOE provides in its PSHA methodology the simple statement that "the selection criteria **did not include** a criterion for willingness to publicly disclose potential conflicts of interest, as recommended in NUREG-1563." SAR at 5.4-7 (emphasis added). Not only did DOE's criteria for selection of the subject-matter experts **not** preclude conflicts of interest or bias, it literally **invited** them: one basis for hiring was "specific knowledge of the Yucca Mountain area." PSHA 2-7. Moreover, when conflict information was discovered, it was not disclosed in the PSHA, but squirreled away in unpublished files: "Each expert completed a conflict of interest statement, which is included as part of the records of the PSHA Project. None of the selected experts was precluded from participating in the Project on the basis of conflicts of interest." PSHA 2-9.

DOE's complete departure from two critical requisites of the methodology prescribed by NRC, and allegedly embraced by DOE, is more than a technical violation. Rather, both of those departures are symptomatic of an overall expert elicitation methodology employed by DOE which runs contrary to the letter and the spirit of NUREG-1563 in a way that permits DOE to improperly secure the desired result of its expert elicitation through the improper selection and training of the experts and the improper elicitation of their heavily pressured and frequently revised opinions.

NRC's NUREG-1563 discusses the types of experts who must be assembled for the conduct of a credible expert elicitation. According to NRC, an unbiased panel of "normative" experts must select a group of "equally unbiased" world renowned "subject-matter experts," provide them with data (supplied by equally unbiased technical experts) concerning the issues in question, and then free them to analyze the data and formulate conclusions and opinions. Only after each of the subject-matter experts reports his or her opinion, the entire group of experts may be brought together in an effort to see if a consensus or common ground can be reached on some or all of the issues under consideration. Among the significant criteria articulated by NRC for a credible elicitation:

- Because the "normative" experts who select the subject-matter experts may influence the outcome of the elicitation by the manner in which opinions are elicited, care should be taken in their selection to ensure they can perform in an objective and impartial manner (LSN# DN200265379 at 15).
- The "generalist" technical experts, engaged to provide technical background data to the subject-matter experts for their analysis, must also be objective and impartial. *Id*.
- It cannot be emphasized enough that, because of the reviewer's potential need to examine an individual expert's judgments and reasoning bases, the professional judgment of each subject-matter expert must be explicitly documented (subsequently, an effort may be made to aggregate the judgments of the various experts, but it is essential that the individual experts' initial opinions must be preserved). The documentation should clearly distinguish between the opinions provided by each subject-matter expert and any subsequent processing of that information or aggregation of the judgments of different experts. *Id*. at 18.
- The NRC believes that even the effective implementation of a proper elicitation process cannot guarantee acceptance of the technical conclusions; however, the use of a flawed process or improper implementation of a good process cannot help but cast serious doubt on the quality of the conclusions. One of the stated purposes of NUREG-1563 is to describe **acceptable** procedures for conducting expert elicitation when formally elicited judgments are used to support demonstration of compliance with NRC's geologic repository disposal regulations. *Id*. at 4.

- When expert judgments are used to support a demonstration of compliance, sufficient documentation should exist to allow external examination of why the judgments were used instead of obtaining objective information. *Id*. at 19. (When, as here, some ten years has expired between the time of the elicitation and its utilization in direct support of the LA, with DOE expending a half billion dollars a year on continued analysis of YMP site characteristics, it raises the question whether this aged information has any remaining viability, and why in the ensuing decade, DOE has not filled any void in its knowledge of seismic hazards and their analysis. Indeed, the data relied upon in the PSHA is "mature" to say the least: "The assessment of seismic hazards relied upon the findings of scientific investigations carried out over the past 20 years or more to study the Yucca Mountain vicinity." PSHA at ES-1. The goal for the utilization of the PSHA was not the LA at all, but rather a decade-old predecessor: "The fault displacement and ground motion hazard results of the PSHA Project will be used directly together with the refined component model response analyses, in subsequent TSPA-VA." PSHA at 1-6. The TSPA-VA was completed in 1998, more than ten years before DOE's recent submission of its LA.)
- NUREG-1563 contemplates that the same criteria should be applied in the selection of generalist and normative experts as are employed with respect to subject-matter experts and states "this is particularly true as it relates to the criterion concerning the appearance of bias or conflict of interest owing to the influence the generalist and normative expert can have on the outcome of any potential elicitation. *Id*. at 23.
- NRC recognized in NUREG-1563 that the opinions of the subject-matter experts may be dictated by the data which they are provided upon which to base their opinions: "The judgments of the subject-matter experts may be influenced by the type of information they receive, and the manner in which that information is presented. . . . Biasing may be introduced at this very influential point, and credibility of the elicitation could be reduced if a suitably broad range of information on a particular issue is not made available. *Id*. at 26.
- Finally, "the Staff cannot predict what weight, if any, the Licensing Board would attribute to expert opinion derived from an expert elicitation." *Id*. at 4.

Contrary to the entire philosophy thus articulated in NUREG-1563, and its own commitment to follow that guidance, DOE created a Project Management Team (responsible to carry out the project and select subject-matter experts) comprised entirely of DOE contractors. Two types of subject-matter experts were engaged. Six small teams of experts in seismic source and fault displacement evaluation (SSFD) comprised 18 individuals, almost half of whom were from DOE contractors. Second, a smaller team of ground motion (GM) experts was engaged, a majority of whom worked for DOE contractors. Existence of potential conflicts is sometimes difficult to ferret out, because of the PSHA's non-disclosure of the potential conflict forms filled out by the experts, and also because that information which **was** provided sometimes conceals an affiliation which takes further research to penetrate. For example, the employer of one of the experts (GEO-HAZ Consulting, Inc.) lists on its website as clients some six other DOE Yucca Mountain project contractors; and another of the selected experts is from Pacific Engineering and Analysis, which *inter alia*, co-wrote (along with other DOE contractors) a paper entitled "Development of Earthquake Ground Motions for Yucca Mountain" (2004) (LSN# DN2002213414) which was incorporated by Bechtel's May 2004 seismic analysis for the project.

In a gross departure from NUREG-1563 methodology, the independent opinions of the experts were **not** elicited prior to their being "trained" and manipulated through a series of workshops and field trips. Only after tentative views had been disclosed and made the subject of debate, revision, challenge, revision, attack, and revision, were the "independent" elicitations finally conducted. Given the overwhelming DOE/contractor composition of the Project Management Team, this incremental methodology was calculated to have the effect of revising and orchestrating the "independent" thinking of the subject-matter experts. This is **precisely** the lack of objectivity forbidden by the most basic tenets of NUREG-1563. The outcome of the PSHA was inalterably tainted by the composition of the teams who selected and trained the subject-matter experts, without any need for any bias on the part of those individuals themselves. However, *see supra*, the selection of DOE contractor personnel for both the SSFD and GM subject matter expert groups was pervasive.

The PSHA expert elicitation, as conducted by DOE, is totally inadequate and should not be accepted in support of the LA due to its stunning departures from the principles of objectivity and independence with respect to (1) the selection of the Project Management Team members, (2) the selection of subject-matter experts, and (3) the conduct of the elicitation itself, with multiple preliminary phases in which the actual independent opinions of the subject-matter experts were disregarded until **after** they had been massaged and revised multiple times through workshops and field trips conducted by an overwhelmingly DOE-biased team, until those opinions were deemed acceptable for elicitation. The use in the LA of biased opinion, shaped by a flawed and biased selection, education, and elicitation process creates the risk of introducing error into the LA and its analyses which could lead to adverse health and safety consequences for workers and the public.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsections 5, 5.4, 5.4.2, and similar subsections, and QARD 2.2.9, 2.2.13.B.7, and similar subsections, which describe DOE's conduct of an expert elicitation relating to PSHA that is directly relied upon in its License Application, because they disclose a methodology so contrary to that which is required and that which DOE committed to employ, as to render the PSHA inadequate and unusable in support of DOE's License Application.

NEV-SAFETY-167 - PROBABILISTIC VOLCANIC HAZARD ANALYSIS EXPERT ELICITATION

1. A statement of the contention itself

SAR Section 5, Subsections 5.1, 5.4, 5.4.1, and similar subsections, and QARD 2.2.9, 2.2.13.B.7, and similar subsections, which describe DOE's conduct of an expert elicitation relating to Probabilistic Volcanic Hazard Analysis (PVHA) that is directly relied upon in its License Application (as well as the expert elicitation itself, DEN000861156), disclose a methodology so contrary to that which is required and that which DOE committed to employ, as to render the PVHA inadequate and unusable in support of DOE's License Application.

2. A brief summary of the basis for the contention

DOE asserts in SAR Subsection 5.4 that its subsequent Subsection 5.4.1 regarding the PVHA complies with the requirements of 10 C.F.R. § 63.21(c)(19) and the applicable portions of NUREG-1804 for the conduct of expert elicitations to be relied upon in the LA; however, DOE admits in SAR Subsection 5.4 that "the process used to conduct an expert elicitation can have a significant effect on the results of the elicitation," and in that regard DOE's procedure for the conduct of the PVHA does not meet the requirements of 10 C.F.R. § 63.21(c)(19) or the guidance of NUREG-1804, and contradicts both the letter and the spirit of those references by employing processes for the selection of participating experts, their preparation and training, and the elicitation of their opinions, which are calculated to be biased and to result in an outcome predetermined by DOE, rather than an independent objective assessment.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.21(c)(19) requires DOE to provide a detailed description of its implementation of expert elicitation, on any occasion in which DOE elects to utilize that methodology in support of its LA. Pursuant to 10 C.F.R. §§ 63.31(a)(1) and (2), the NRC will not authorize construction of a geologic repository operations area at Yucca Mountain unless it determines, among other things, that there is a reasonable expectation that radioactive materials described in the application can be received and possessed without unreasonable risk to the health and safety of the public. Where, as here, that determination by DOE is directly dependent upon the results of its PVHA, DOE's LA should be denied if its utilization of expert elicitation is flawed and inadequate.

The detailed requirements for an appropriate expert elicitation are set out by NRC in NUREG-1563 (LSN# DN2002065379), and its specific expectations for compliance in any instance where DOE elects to rely on expert elicitation are set out in the acceptance criteria of NUREG-1804. While DOE claims to follow the guidance of NUREG-1563 in satisfying the requirements of 10 C.F.R. § 63.21(c)(19), DOE does not do so. DOE asserts in QARD 2.2.9 and 2.2.13.B.7 that its own expert elicitations "shall be conducted in accordance with NUREG-1563, Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program (Nov. 1996) with a single exception," but DOE fails to do so in its implementation of the PVHA, details of which are explained by DOE at SAR Subsection 5.4.1. This contention alleges non-compliance with these regulatory provisions (and DOE's own commitments) and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The point of a properly conducted expert elicitation is not to undertake new experiments or new site characterization; rather, it is to present evenhandedly selected existing data (chosen by independent, unbiased technical experts) to a panel of world-class experts in the particular field in order to secure their (again, independent and unbiased) opinions. By this approach the quality and relevance of the available data are appropriately weighed and their value is enhanced by being informed by the broader knowledge base of the experts involved in the process. However, in the PVHA, those who conducted the PVHA and those who selected the experts, selected the data to be given to the expert panel, conducted the elicitation of the subject-matter experts' opinions, and prepared the final report resulting from the elicitation were overwhelmingly tied to DOE or its contractors. This is a recipe for an improperly conducted elicitation and an unreliable outcome. In DOE's conduct of its PVHA, instead of receiving **independent opinions** of subject-matter experts, with documentation of the rationale for any revisions made in those experts' opinions, DOE instead selected subject-matter experts by a biased group, trained and indoctrinated them by a biased group, and elicited their expert opinions only **after** numerous workshops and field trips (focused by biased leaders) were conducted for the specific purpose of testing, challenging, and revising those opinions, all implemented by a predominantly DOE-biased team.

DOE committed in SAR Subsection 5.4 and in QARD 2.2.9 and 2.2.13.B.7 to strictly embrace the guidance contained in NRC's NUREG-1563 as its methodology in meeting the requisites of 10 C.F.R. § 63.21(c)(19) for the use of expert elicitation in support of the LA. In the same two references, DOE committed to explain the justification for any instance in which it departed from the guidance of NUREG-1563. DOE neither followed the guidance of NUREG-

1563, nor did it explain the rationale for its departures from doing so. In embracing NUREG-1563, DOE was required to do both: the primary components of NRC's review of DOE's expert elicitation compliance are contained at NUREG-1804 Section 2.5.4.1(2) (providing that the Staff will evaluate the extent to which the guidance in NUREG-1563 was used by DOE to perform expert elicitations) and Section 2.5.4.1(9) (the Staff will verify that DOE provided an adequate explanation for any variance from NUREG-1563 guidance).

DOE asserts in QARD 2.2.13.B.7 that there is only a single exception to its otherwise complete commitment to the procedures set out in NUREG-1563. Specifically, the exception relates to "documenting the rationale for any revisions to elicited evaluations after the experts receive feedback on their initial evaluations." True to its word, DOE **did** omit in its PVHA documentation of the experts' rationale for revising their elicitations after receiving feedback. This is a very important omission and departure from NUREG-1563 in itself, since it is calculated to prevent exposing the degree to which the DOE process (aimed at pressuring the subject-matter experts into conformity with DOE's views) was successful or not. The point here is that DOE promised in SAR Subsection 5.4 to explain "any variance between the Staff guidance in NUREG-1563 and the DOE conduct of expert elicitations," and it did not do so. DOE does not attempt to give a rationale for its decision to exclude any explanation of the reasons why experts changed their opinions after receiving DOE input on their initial decisions. Rather, DOE simply states "OCRWM does not require documentation of the rationale for revisions to an expert's initial assessment." QARD 2.2.13.B.7. That is not a rationale; it is simply a statement of the non-conforming DOE practice, which DOE does not attempt to explain, but whose calculated effect is obvious.

The second particular in which DOE neither follows the procedures set out in NUREG-1563, nor makes any effort to explain why not, relates to disclosure of conflicts of interest on the part of subject-matter experts – again, a critical determinant of their likelihood to give opinions satisfactory to DOE, rather than to speak with independence. NUREG-1563 Section 2.5.4.2(2)(e) requires that the NRC Staff verify that DOE's expert selection criteria comply with the requirement that prospective experts must be "willing to publicly disclose potential conflicts of interest." Contrary to this provision, DOE provides in its PVHA methodology the simple statement that "the selection criteria **did not include** a criterion for willingness to publicly disclose potential conflicts of interest, as recommended in NUREG-1563." SAR at 5.4-4 (emphasis added). Not only did DOE's criteria for selection of the subject-matter experts **not** preclude conflicts of interest, it literally **invited** them: "Prior familiarity with the data available for the proposed Yucca Mountain site will be an asset but **not a requirement** for participation." PVHA at 2-22 (emphasis added).

DOE's complete departure from two critical requisites of the methodology prescribed by NRC, and allegedly embraced by DOE, is more than a technical violation. Rather, both of those departures are symptomatic of an overall expert elicitation methodology employed by DOE which runs contrary to the letter and the spirit of NUREG-1563 in a way that permits DOE to improperly secure the desired result of its expert elicitation through the improper selection and training of the experts and the improper elicitation of their heavily pressured and frequently revised opinions.

NRC's NUREG-1563 discusses the types of experts who must be assembled for the conduct of a credible expert elicitation. According to NRC, an unbiased panel of "normative" experts must select a group of "equally unbiased" world renowned "subject-matter experts," provide them with data (supplied by equally unbiased technical experts) concerning the issues in question, and then free them to analyze the data and formulate conclusions and opinions. Only after each of the subject-matter experts reports his or her opinion, the entire group of experts may be brought together in an effort to see if a consensus or common ground can be reached on some or all of the issues under consideration. Among the significant criteria articulated by NRC for a credible elicitation:

- Because the "normative" experts who select the subject-matter experts may influence the outcome of the elicitation by the manner in which opinions are elicited, care should be taken in their selection to ensure they can perform in an objective and impartial manner (LSN# DN2002065379 at 15).
- The "generalist" technical experts, engaged to provide technical background data to the subject-matter experts for their analysis, must also be objective and impartial. *Id*.
- It cannot be emphasized enough that, because of the reviewer's potential need to examine an individual expert's judgments and reasoning bases, the professional judgment of each subject-matter expert must be explicitly documented (subsequently, an effort may be made to aggregate the judgments of the various experts, but it is essential that the individual experts' initial opinions must be preserved). The documentation should clearly distinguish between the opinions provided by each subject-matter expert and any subsequent processing of that information or aggregation of the judgments of different experts. *Id*. at 18.
- The NRC believes that even the effective implementation of a proper elicitation process cannot guarantee acceptance of the technical conclusions; however, the use of a flawed process or improper implementation of a good process cannot help but cast serious doubt on the quality of the conclusions. One of the stated purposes of NUREG-1563 is to describe **acceptable** procedures for conducting expert elicitation when formally elicited judgments are used to support demonstration of compliance with NRC's geologic repository disposal regulations. *Id*. at 4.
- When expert judgments are used to support a demonstration of compliance, sufficient documentation should exist to allow external examination of why the judgments were used instead of obtaining objective information. *Id*. at 19. (Here, DOE cannot justify the use of its 1996 PVHA in direct support of its LA. The information on which it was based is obviously more than 12 years old. The panel was instructed to

strictly limit their view and opinions to a period of only 10,000 years, a period rejected by the Court of Appeals for the D.C. Circuit in 2004, and replaced by a one-million-year standard, which is not addressed in DOE's 1996 PVHA. Moreover, DOE secured new and significantly different aeromagnetic information in 2004 which illustrates that the information relied upon for the 1996 PVHA is inaccurate, and results in incorrect calculations and results regarding the probability of volcanic activity in the Yucca Mountain area.)

- NUREG-1563 contemplates that the same criteria should be applied in the selection of generalist and normative experts as are employed with respect to subject-matter experts and states "this is particularly true as it relates to the criterion concerning the appearance of bias or conflict of interest owing to the influence the generalist and normative expert can have on the outcome of any potential elicitation." *Id*. at 23.
- NRC recognized in NUREG-1563 that the opinions of the subject-matter experts may be dictated by the data which they are provided upon which to base their opinions: "The judgments of the subject-matter experts may be influenced by the type of information they receive, and the manner in which that information is presented. . . . Biasing may be introduced at this very influential point, and credibility of the elicitation could be reduced if a suitably broad range of information on a particular issue is not made available." *Id*. at 26.
- Finally, "the Staff cannot predict what weight, if any, the Licensing Board would attribute to expert opinion derived from an expert elicitation." *Id*. at 4.

Contrary to the entire philosophy thus articulated in NUREG-1563, and its own commitment to follow that guidance, DOE created a Methodology Development Team (responsible to carry out the project and select subject-matter experts) comprised of 10 persons, 8 of whom were DOE contractors; well over half the technical specialists (whose assignment was to provide the subject-matter experts with documentation and specialized data and training through workshops and field trips) were also from the ranks of DOE contractors. It is not surprising that the expert selection criteria and identity of the selectors would result in a panel of experts laced with personnel from DOE contractors. Perhaps surprising is the fact that included on the panel, presumably as its anticipated leader, was the single individual most involved for DOE for the many-year period prior to the conduct of the PVHA whose entire work effort was dedicated to the analysis of volcanism at Yucca. To quote the PVHA (at A-1): "Dr. Bruce M. Crowe has been with Los Alamos National Laboratory for 20 years at the time the 1996 PVHA was prepared. He has initiated volcanic hazard studies of basaltic volcanism in the Yucca Mountain region in 1979 as a joint project with the USGS. He developed and applied the approach used in probabilistic volcanic hazard assessment for the Yucca Mountain region in the early 1980s and directed the volcanism project for DOE from the early 1980s until 1994.... Dr. Crowe has been Group Leader of the Applied Geosciences and the Isotope Geochemistry groups at Los Alamos Group and served as Deputy Technical Project Officer, the Technical Project Officer, and the Geochemistry Coordinator for the programs conducted by the Los Alamos National Laboratory for the Yucca Mountain Site Characterization Project (YMP). Dr. Crowe currently is the Principal Investigator of the Probabilistic Volcanic Hazard Assessment aspects of the Los Alamos volcanism program."

In a gross departure from NUREG-1563 methodology, the independent opinions of the experts were **not** elicited prior to their being "trained" and manipulated through a series of workshops and field trips. Only after tentative views had been disclosed and made the subject of debate, revision, challenge, revision, attack, and revision, were the "independent" elicitations finally conducted. Given the overwhelming DOE/contractor composition of the Methodology Development Team and the technical specialist group, this incremental methodology was calculated to have the effect of revising and orchestrating the "independent" thinking of the subject-matter experts. This is **precisely** the lack of objectivity forbidden by the most basic tenets of NUREG-1563. The outcome of the PVHA was inalterably tainted by the composition of the teams who selected and trained the subject-matter experts, setting aside the affiliation of some of those individuals and their work under the leadership of Dr. Crowe.

The PVHA, as conducted by DOE, is totally inadequate and should not be accepted in support of the LA due to its stunning departures from the principles of objectivity and independence with respect to (1) the selection of the Methodology Development Team members, (2) the selection of technical specialist experts, (3) the selection of subject-matter experts, and (4) the conduct of the elicitation itself, with multiple preliminary phases in which the actual independent opinions of the subject-matter experts were disregarded until **after** they had been massaged and revised multiple times through workshops and field trips conducted by an overwhelmingly DOE-biased team, until those opinions were deemed acceptable for elicitation. The use in the LA of biased opinion, shaped by a flawed and biased selection, education, and elicitation process creates the risk of introducing error into the LA and its analyses which could lead to adverse health and safety consequences for workers and the public.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsections 5, 5.1, 5.4, 5.4.1, and similar subsections, and QARD 2.2.9, 2.2.13.B.7, and similar subsections, which describe DOE's conduct of an expert elicitation relating to PVHA that is directly relied upon in its License Application, because they disclose a methodology so contrary to that which is required and that which DOE committed to employ, as to render the PVHA inadequate and unusable in support of DOE's License Application.

(y) Retrievability

NEV-SAFETY-168 - RETRIEVAL PRACTICALITY

1. A statement of the contention itself

The descriptions of plans provided in SAR Subsection 1.11 and similar subsections are not sufficiently detailed to demonstrate waste packages can be retrieved.

2. A brief summary of the basis for the contention

Because DOE has not designed, prototyped, tested, or demonstrated in any practical manner the equipment that it proposes to use to retrieve waste packages, in the subsurface conditions that will exist in the repository under normal and off-normal conditions, the applicant has not demonstrated the waste packages can be retrieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize issuance of a construction authorization for Yucca Mountain if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the application to satisfy the requirements in 10 C.F.R. § 63.21 including (c)(7) which specifies the Safety Analysis Report must include a description of plans for retrieval and alternate storage of the radioactive wastes, should retrieval be necessary. 10 C.F.R. § 63.2 defines retrieval as the act of permanently removing radioactive waste from the underground location at which the waste had been previously emplaced for disposal. This contention alleges non-compliance with these

regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding. 10 C.F.R. § 63.111(e) requires the repository to be "designed to preserve the option of waste retrieval." In particular, the repository must be designed so that "any or all of the emplaced waste could be retrieved on a reasonable schedule . . . ." These implement Section 122 of the NWPA, which requires the repository to be designed to "permit the retrieval of any spent nuclear fuel." This contention alleges a violation of these statutory and regulatory provisions.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Subsection 1.11 of the SAR provides an overview of the description of plans for retrieval and alternative storage of radioactive wastes. A sufficiently detailed description of plans necessary to demonstrate the waste packages can be retrieved is not provided in this section or its subsections. A quote from Subsection 1.11 at 1.11-1 to 2 (emphasis added):

> Specific plans for retrieval will be developed and defined in detail should the need for retrieval be identified. In the event of a decision to retrieve, safety **analyses** will be performed for those retrieval actions and operations necessary to safely **remove** the waste from the underground emplacement area . . .These analyses will include the specific details about how retrieval operations would be performed.

Subsection 1.3.1.2.8 at 1.3.1-34 describes retrieval using the same operational concepts as emplacement but in reverse order using the same or similar SSC's as those used for waste package transportation and emplacement.

Subsection 1.11.1 at 1.11-2, *Retrieval Plans* goes on to say development of detailed plans for the retrieval of waste packages would be driven by the reason for retrieval, whereas Subsection 1.11.1.1.1 at 1.11-4 states retrieval operations would use emplacement equipment or equipment developed for retrieval and to be described in an amendment to the license application. "Such equipment and facilities, along with the measures that may need to be implemented to support the operational readiness, for the purpose of retrieval, will be evaluated at the time a decision to retrieve is made." *See* SAR Subsection 1.11.1.1.1 at 1.11-4.

However, to assure that the design will allow retrieval, the following conditions that are known to exist in mines including emplacement drifts must be addressed:

The structures, system or components (SSCs) necessary for retrieval must be sufficiently developed and documented in order to allow evaluation of the reliability and likely performance of the equipment required to be able to advance to each of the approximately 11,400 waste packages located in the approximately 64 kilometers of tunnels, pick up the waste package and then return to surface without a single equipment failure or other event that prevents retrieval. Subsection 1.11.1.2.2 lists a series of operational events that may potentially impact retrieval operations. ***No descriptions of plans to overcome these events are even identified.***

Derailment of the TEV is listed as an event that could potentially interfere with retrieval. Depending on where the TEV was to fail, it could not only prevent retrieval of the waste package loaded on the TEV, but the TEV could block access to one or more drifts preventing retrieval of multiple waste packages. In addition, there are other TEV failure mechanisms, such as simple mechanical failure. The TEV and other equipment that may be necessary for retrieval and which has yet even to be identified are no more than idealized incomplete concepts.

In contrast, the Swedish Nuclear Fuel and Waste Management Company has designed and conducted field testing of the equipment necessary to retrieve waste packages as part of its high level radioactive waste repository, even though, unlike Yucca Mountain, retrievability is not a requirement of the Swedish program. *See* "Technical Report TR-07-12, RD&D Programme 2007, Programme for Research, Development, and Demonstration of Methods for the Management and Disposal of Nuclear Waste" (09/01/2007), LSN# NEV000005491, Section 17 at 207-209. Therefore, the level of description of plans is not consistent with a comparable facility which, unlike Yucca Mountain, *has no retrievability requirement*. The description of plans for the waste package retrieval equipment is not sufficient to demonstrate that it will work, and therefore, the ability to retrieve waste has not been demonstrated by the LA as required by the applicable rules. This is a major deficiency and therefore the license should be denied.

Furthermore, DOE relies on practically nonexistent drift inspection and maintenance plans to address ground support failure and associated rock fall and drift collapse. DOE has not demonstrated how it can and will inspect or maintain the drifts after waste package placement and before the end of the ventilation period (~50 years) under the dusty and high radiation conditions that will exist in the emplacement drifts. This equipment has not been designed, prototyped, or demonstrated to be able to perform the inspection and maintenance functions that are assumed by the applicant. By the time retrieval is necessary access to one or more drifts may not even be possible.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 1.11 because the description of plans for retrieval is not sufficiently detailed to demonstrate waste packages can be retrieved. Therefore, SAR Subsection 1.11 is both materially incomplete and inadequate, because it does satisfy the requirements in 10 C.F.R. § 63.21, including (c)(7), which specifies the Safety Analysis Report must include a description of plans for retrieval and alternate storage of the radioactive wastes, should retrieval be necessary.

NEV-SAFETY-169 - DEFERRED RETRIEVAL PLANS

1. A statement of the contention itself

Legal issue: The LA cannot be granted because it includes only a conceptual discussion of retrieval plans and no actual retrieval plans are included or referenced.

2. A brief summary of the basis for the contention

Subsection 1.11 of the SAR at 1.11-1 through 1.11-16 describes DOE proposed retrieval plan in a scant sixteen pages, and provides only limited information about basic retrieval concepts. It promises that "[s]pecific plans for retrieval will be developed and defined in detail should the need for retrieval be identified." SAR Subsection 1.11 at 1.11-1 and 1.11-2. However, this approach effectively eliminates the possibility that there will be full and adequate consideration of retrieval issues before wastes are emplaced, after which the range of safe and viable plans may be severely limited, and violates 10 C.F.R. § 63.21(c)(7).

3. A demonstration that the contention is within the scope of the hearing

This issue must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. § 63.31(a)(1) and (2), that there is reasonable assurance of safety, and to find that the application complies with 10 C.F.R. § 63.21(c)(7), as required by 10 C.F.R. § 63.31(a)(3), and the issue is within the scope of the hearing as provided in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This issue must be addressed and resolved in order for the NRC to find, as required by 10 C.F.R. § 63.31(a)(1) and (2), that there is reasonable assurance of safety, and to find that the application complies with 10 C.F.R. § 63.21(c)(7), as required by 10 C.F.R. § 63.31(a)(3). The issue is therefore material.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Subsection 1.11 of the SAR describes DOE's proposed retrieval plan in a scant sixteen pages – from 1.11-1 through 1.11-16. It provides only limited information about retrieval concepts. It promises that "[s]pecific plans for retrieval will be developed and defined in detail should the need for retrieval be identified." SAR Subsection 1.11 at 1.11-1 and 1.11-2. However, this approach effectively eliminates the possibility that there will be full and adequate consideration of retrieval issues on a timely basis, before wastes are emplaced, because after emplacement the range of safe and viable plans may be severely limited.

10 C.F.R. § 63.21(c)(7) requires that the safety analysis report include "[a] description of plans for retrieval and alternate storage of the radioactive waste, should retrieval be necessary." The requirement that plans be described suggests that plans must exist or otherwise they could not be described, and the rulemaking history of Part 63 indicates clearly that full plans were indeed required to be reviewed fully by the NRC before issuance of the construction authorization. *See* 66 Fed. Reg. 55732, 55743 (11/2/2001).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the adequacy of Subsection 1.11 of the SAR at 1.11-1 through 1.11-16. Reasons are given in paragraph 5 above. In brief, Subsection 1.11 of the SAR at 1.11-1 through 1.11-16 describes DOE's proposed retrieval plan in a scant sixteen pages, and provides only limited information describing retrieval concepts. It promises that "[s]pecific plans for retrieval will be developed and defined in detail should the need for retrieval be identified." SAR Subsection 1.11 at 1.11-1 and 1.11-2. However, this approach effectively eliminates the possibility that there will be adequate consideration of retrieval before wastes are emplaced, after which it may be too late, and violates 10 C.F.R. § 63.21(c)(7).

(z) Performance Margin Analysis

NEV-SAFETY-170 - CONSERVATISMS AND THE PMA

1. A statement of the contention itself

The PMA in Subsection 2.4.2.3.2.3.2.4 of the SAR, and referred to in related subsections, is offered to validate or provide confidence in the TSPA, but it cannot be used for these purposes, or to demonstrate net conservatisms or margins in the TSPA, because the PMA (LSN# DN20023695678) assumes that certain important parts of the TSPA are conservative when, in fact, these parts are not adequately supported, are biased in favor of compliance, or are simply wrong.

2. A brief summary of the basis for the contention

Subsection 2.4.2.3.2.3.2.4 of the SAR attempts to validate or provide confidence in the TSPA, and to demonstrate margins or conservatisms in the TSPA, by offering a PMA that replaces certain assumptions in the TSPA that are claimed to be conservative (*i.e.*, lead to an overestimation of RMEI dose) with others that are considered less conservative or realistic. However, the fundamental premise for the PMA, that certain assumptions in the TSPA are conservative, is flawed because these assumptions are unsupported, are biased in favor of compliance, or are simply wrong.

3. A demonstration that the contention is within the scope of the hearing

This contention challenges compliance with 10 C.F.R. §§ 63.114(b), 63.303, and 63.304, and is within the scope of the hearing as provided in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This contention challenges compliance with 10 C.F.R. §§ 63.114(b), 63.303, and 63.304. 10 C.F.R. §§ 63.114(b) is within Subpart E of 10 C.F.R. Part 60, and 10 C.F.R. § 63.31(a)(3)(ii) provides that issuance of a construction authorization requires a finding of compliance with Subpart E. Further, 10 C.F.R. § 63.113(d) of Subpart E requires a finding of compliance with 10 C.F.R. § 63.303, and 10 C.F.R. § 63.303 implicates 10 C.F.R. § 63.304. The issue is therefore material.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Subsection 2.4.2.3.2.3.2.4 of the SAR, and related subsections, attempt to validate or provide confidence in the TSPA and to demonstrate margins or conservatisms in the TSPA by offering a PMA that replaces certain assumptions in the TSPA that are claimed to be conservative (*i.e.*, lead to an overestimation of RMEI dose) with others that are considered less conservative or realistic. However, the fundamental premise for the PMA, that certain assumptions in the TSPA are conservative, is flawed because these assumptions are unsupported, are biased in favor of compliance, or are simply wrong.

This is demonstrated generally by the PMA (1/19/2007), LSN# DN20023695678 at 4, which describes the conceptual foundation of the PMA and states that:

> [w]here information is lacking or the degree of complexity exceeds the ability of suitable methodologies to provide realistic representations of uncertainty, the approach [of the TSPA] has been to simplify and bound the representations. Generally, this approach was followed in technical areas where reducing the uncertainty was not feasible, such that additional data would not significantly reduce the uncertainty, or where the uncertainty does not significantly affect the performance assessment analyses because the TSPA-LA Model's results are insensitive to that particular component.

However, as a general proposition, if information is lacking or the degree of complexity exceeds the ability of suitable methodologies to provide realistic representations of uncertainty, it cannot be established that the representations used are in fact bounding or conservative, the apparent assumption of the PMA.

This is further demonstrated by NEV-SAFETY-12, NEV-SAFETY-20, NEV-SAFETY-28, NEV-SAFETY-31, NEV-SAFETY-44, NEV-SAFETY-45, NEV-SAFETY-47, NEV-SAFETY-53, NEV-SAFETY-61, NEV-SAFETY-62, NEV-SAFETY-63, NEV-SAFETY-64, NEV-SAFETY-65, NEV-SAFETY-66, NEV-SAFETY-75, NEV-SAFETY-82, NEV-SAFETY-86, NEV-SAFETY-90, NEV-SAFETY-100, NEV-SAFETY-101, NEV-SAFETY-103, NEV-SAFETY-104, NEV-SAFETY-105, NEV-SAFETY-106, and NEV-SAFETY-127.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the PMA in Subsection 2.4.2.3.2.3.2.4 of the SAR, and referred to in related subsections, which is offered to validate or provide confidence in the TSPA. The reasons are given in paragraph 5 above and may be summarized as follows. The fundamental premise for the PMA, that certain assumptions in the TSPA are conservative, is flawed because these assumptions are unsupported, are biased in favor of compliance, or are simply wrong.

NEV-SAFETY-171 - PMA AND QA

1. <u>A statement of the contention itself</u>

Legal issue: The PMA in Subsection 2.4.2.3.2.3.2.4 of the SAR, and referred to in related SAR subsections, is offered to validate or provide confidence in the TSPA and to demonstrate net conservatisms or margins in the TSPA, but it cannot lawfully be used for these purposes because it relies on data and models that are not qualified pursuant to DOE's quality assurance program.

2. <u>A brief summary of the basis for the contention</u>

Data and models offered to prove compliance with NRC's safety requirements in 10 C.F.R. Part 63 must be developed or qualified pursuant to a quality assurance program that complies with 10 C.F.R. Part 63, Subpart G. Because the PMA uses data and models that were not subject to DOE's quality assurance program, or qualified under that program, it cannot be used to prove any aspect of compliance.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

This contention challenges compliance with 10 C.F.R. §§ 63.114(b), 63.141, 63.142, 63.143, 63.303, 63.304, and is within the scope of the hearing as provided in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

This contention challenges compliance with 10 C.F.R. §§ 63.114(b), 63.303, and 63.304. 10 C.F.R. §§ 63.114(b) is within Subpart E of 10 C.F.R. Part 60, and 10 C.F.R. § 63.31(a)(3)(ii) provides that issuance of a construction authorization requires a finding of compliance with Subpart E. Further, 10 C.F.R. § 63.113(d) of Subpart E requires a finding of compliance with 10 C.F.R. § 63.303, and 10 C.F.R. § 63.303 implicates 10 C.F.R. § 63.304. The issue is therefore material. This contention also challenges compliance with 10 C.F.R. §§ 63.141, 63.142, and 63.143, all within Subpart G of 10 C.F.R. Part 63. 10 C.F.R. § 63.31(a)(3)(iii) requires a finding of compliance with Subpart G before a construction authorization can be issued.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Data and models offered to prove compliance with NRC's safety requirements in 10 C.F.R. Part 63 must be developed or qualified pursuant to a quality assurance program that complies with 10 C.F.R. Part 63, Subpart G. *See* 10 C.F.R. § 63.141 (which provides that quality assurance covers all actions needed to provide adequate protection and all actions important to waste isolation) and 10 C.F.R. § 63.142(a) (which provides that quality assurance applies to the acquisition, control, and analysis of data and scientific studies, which would include models). Since the PMA is offered as a part of DOE's compliance case, it is subject to quality assurance requirements. The quality assurance program includes documentation and validation. *See, e.g.*, 10 C.F.R. §§ 63.142(b)(1), 63.142(c)(2), 63.142(c)(3), 63.142(c)(3), and 63.142(r).

The PMA, which describes (at 2) the conceptual basis for the PMA, states that "[a]lternatives considered in the PMA need to be technically sound and credible and consistent with currently available information, but they do not need to meet the full documentation (and validation) expectations of the compliance models presented in the baseline AMRs." Thus the PMA was not considered subject to quality assurance, and it cannot be used validate or provide confidence in the TSPA, or to demonstrate net conservatisms or margins in the TSPA, as a part of DOE's compliance case.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the PMA in Subsection 2.4.2.3.2.3.2.4 of the SAR, and referred to in related subsections, which is offered to validate or provide confidence in the TSPA, and to demonstrate net conservatisms or margins in the TSPA, because it relies on data and models that are not qualified pursuant to DOE's quality assurance program. Supporting reasons are explained more fully above.

(aa) Inspection and Verification (also Pre-Closure Activities)

NEV-SAFETY-172 - INSPECTION AND VERIFICATION OF TAD

1. <u>A statement of the contention itself</u>

SAR Subsections 5.0, 5.1, 1.5, 1.5.1, 1.2.1, and similar subsections, and DOE'S QARD (incorporated by reference in the License Application in Chapter 5) Sections 7.1, 7.2, and similar subsections, demonstrate that DOE is required to, but does not intend to, require reasonable assurance with respect to the contents and the proper packaging of those contents by nuclear utilities providing waste to DOE for the proposed repository in transportation, aging, and disposal (TAD) canisters; such quality assurance failure with respect to the important-to-safety (ITS) TAD renders it unusable for emplacement and storage of waste in the proposed Yucca Mountain repository.

2. <u>A brief summary of the basis for the contention</u>

SAR Subsection 5.1 adopts DOE's Quality Assurance Requirements and Description (QARD) as embodying the requirements of the quality assurance (QA) program applicable to quality-related activities at the Yucca Mountain repository, addressing the requirements of 10 C.F.R. § 63.21(c)(20). While SAR Subsections 1.2.1, *et seq*., and 1.5.1, *et seq*., detail DOE's planned utilization of the TAD for the emplacement and storage of high-level waste received from nuclear utilities, in the case of the TAD DOE abdicates its duty with respect to **any** ITS component received at Yucca from an outside source to ensure by inspection, surveillance, audit, and other means of source verification that the component as received has been prepared in accordance with a compliant quality assurance program. DOE's mere assertion that it does not have a right to regulate the activities of nuclear utilities at their reactor sites is woefully inadequate: DOE likewise has no right to enter the premises of any other supplier of any component (goods or services) to Yucca other than by the contract terms under which its relationship with those third parties is established. DOE has attempted and failed, despite proposing to give "incentives," to secure an agreement with nuclear power plant operators with respect to their use, preparation, and loading of TADs. This cannot be raised by DOE as an excuse to abdicate its responsibility to assure the health and safety of workers and the public by applying, and imposing on third-party suppliers of components to Yucca, the same rigid quality assurance requirements which are applied to other components shipped to Yucca from outside.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.21(c)(20) requires that DOE describe the QA program to be applied to the structures, systems, and components important to safety (ITS) and to the engineered and natural barriers important to waste isolation (ITWI). Before the Commission may authorize construction of a geologic repository operations area (GROA) at the Yucca Mountain site, it must first determine that DOE's QA program complies with the required elements of Subpart G of 10 C.F.R. Part 63 (*see* 10 C.F.R. § 63.31(a)(3)(iii)). Subpart G is comprised of 10 C.F.R. §§ 63.141 through 63.144. 10 C.F.R. § 63.142 contains a detailed explanation of the required component parts of an adequate QA program, and Section 63.143 contains the simple mandate: "DOE shall implement a quality assurance program based on the criteria required by Section 63.142." This contention questions whether DOE's plan, set out in its LA, to receive TAD canisters already packed with waste at the site of the utility delivering it, without ensuring that the TADs have been prepared and loaded in compliance with an adequate and compliant QA program,

constitutes a failure on the part of DOE to itself comply with the requisites of Sections 63.142 and 63.143, and therefore raises a material issue.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE's QARD document, which is incorporated by reference in SAR Subsection 5.1, recites the requirements of NRC's regulation 10 C.F.R. Part 63, as well as the detailed criteria of 10 C.F.R. Part 63, Subpart G. The requirements of the QA program are applied to DOE and its contractors for design and construction activities that affect components which are ITS (*see* SAR Subsection 5.0). QA oversight verifies the achievement of QA requirements through audits, surveillances, assessments, and quality reviews (*see* SAR Subsection 5.0). The TAD canister is classified by DOE as a component which is ITS (*see* SAR Subsection 1.5.1.1.1.2.1.3). The Commission will not authorize construction of a repository at Yucca unless it determines that DOE's QA program complies with the requirements of Subpart G (10 C.F.R. §§ 63.141 through 63.144); more specifically, bearing in mind the role of the TAD canister, the Commission will not authorize construction of a repository at Yucca unless it determines that there is a reasonable assurance that the types and amounts of radioactive materials described in the application can be received and possessed in the GROA without unreasonable risk to the health and safety of the public (10 C.F.R. §§ 63.31(a)(1) and (3)(iii)).

With respect to components acquired from third parties located outside the GROA, DOE must establish measures to assure that applicable regulatory requirements, design bases, and other requirements necessary to assure adequate quality are suitably included or referenced in the documents for procurement of material, equipment, and services whether purchased by the licensee or applicant or by its contractors or subcontractors and those procurement documents must require contractors or subcontractors to implement a QA program consistent with the pertinent provisions of 10 C.F.R. Part 63, Subpart G (10 C.F.R. § 63.142(e)). DOE must establish measures to assure that purchased material, equipment, and services, whether purchased directly or through contractors and subcontractors, conform to the procurement documents. These measures must include appropriate provisions for source evaluation and selection and objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products upon delivery (10 C.F.R. §§ 63.142(h) and (h)(i)).

The effectiveness of the control of quality by contractors and subcontractors must be assessed by the licensee or applicant at intervals consistent with the importance of the product or services (10 C.F.R. § 63.142(h)(3)). DOE must establish and execute a program for inspection of activities affecting quality to verify conformance with documented instructions and procedures for accomplishing the activity (10 C.F.R. § 63.142(k)). DOE must carry out a comprehensive system of planned and periodic audits to verify compliance with all aspects of the QA program and to determine the effectiveness of the program (10 C.F.R. § 63.142(s)). DOE acknowledges that the requirements of its QA program are equally applicable to its contractors and suppliers of repository design and construction activities (*see* SAR Subsection 5.0).

DOE undertook in its QARD to address the requirement that it apply to its procurements and acquisitions from third parties the same degree of rigor with which it addressed its own QA program. Section 7.0 of DOE's QARD "establishes requirements for planning and executing quality affecting procurements to ensure that purchased items and services meet specified requirements." *See* QARD (LSN# DEN001574022) at 61. In acquiring products or services for introduction to the Yucca repository, DOE committed to establish the extent of source surveillance and inspections; assign qualified personnel to check, inspect, audit, or witness supplier activities; evaluate supplier performance and evaluate the effectiveness of the supplier's QA program (QARD 7.2.4). DOE, which plans to acquire title to the spent nuclear fuel supplied by the nuclear utilities at the time of its transfer to Yucca, committed that it would employ "source verification" in deciding on acceptance of goods or services by monitoring, witnessing, or observing activities performed by the supplier. DOE explains:

> Source verification is planned and performed by individuals that are trained and qualified in QA practices and concepts in accordance with written procedures to ensure conformance to procurement requirements. Procedures applicable to the method of procurement provide for:
>
> 1. Specification of the characteristics or processes to be witnessed, inspected, or verified and the method of surveillance and the extent of documentation required to audits, surveillances, or inspections to verify the effectiveness of the supplier QA program and quality control activities and to ensure that the supplier complies with QA and technical requirements.

QARD 7.2.8.

DOE is clear with respect to its plans to acquire TAD canisters filled with spent nuclear fuel from nuclear utilities, and equally clear that those canisters will be loaded and sealed at the utility site, totally without the application by DOE of those safeguards which DOE has committed to apply, and seeks to apply, to other third parties from whom it accepts components for delivery to Yucca. (Interestingly, while DOE plans to simply make a "leap of faith" with respect to the adequacy of the contents and the loading of TADs by utilities, it **does** apply its usual QA oversight criteria with respect to AREVA, the company who received a DOE contract to engineer and design TADs at their own facility ("OCRWM Supplier Audit SA-08-29" (08/06/2008), LSN# DEN001601470.)

DOE explains that spent nuclear fuel is received at the repository in sealed canisters that are directly inserted into the waste packages. It further asserts that most commercial spent nuclear fuel will be received in TAD canisters from utility sites, which canisters can either be directly inserted into the waste package or sent to the aging pad if additional cooling of the fuel is required (SAR at 1.5-1). Once a TAD canister has been loaded with commercial spent nuclear fuel, the TAD canister contents will not be repackaged for emplacement. (TAD canisters are also used to thermally age commercial spent nuclear fuel or otherwise match the incoming waste stream and the availability of handling facilities and waste packages (SAR at 1.2.1-4 and 1.2.1-5).) The TAD canister is loaded with spent nuclear fuel and sealed at utilities (SAR at 1.5.1-13). DOE makes it equally clear that its plans for receiving spent fuel in compliant TADs is predicated upon the speculation that it will secure contractual arrangements with the utilities to provide for this and that the utilities will comply with their QA requirements on an "honor system" since they will not be scrutinized by DOE in that process (nor after that process is over, since the TAD canisters will be received by DOE already sealed to be emplaced in the ground without alteration). Thus, DOE assumes "information regarding radioactive material at the waste generator sites will be provided by the records accompanying each shipment received" (SAR at 1.5.1-4). Reciting the terms of the standard contract which has existed between DOE and nuclear utilities for many years, but which does not contemplate utilization of the TAD, DOE acknowledges "contracts with the individual purchasers, based on the standard contract, **will be revised** to permit the use of the TAD canister system when delivering commercial SNF to DOE" (SAR at 1.5.1-4, emphasis added). While DOE recites a laundry list of duties on the part of the nuclear utility which must prepare the TAD canister and load it properly for dispatch to DOE, DOE's duties are limited to transporting and disposing of the canister (SAR at 1.5.1-4).

DOE attempts to excuse its failure to scrutinize the activities of the providers of the most important single component in the planned repository (the spent nuclear fuel) by suggesting that a mere "paper trail" will suffice: "Operations, such as canister and cask loading, are conducted under an NRC-approved quality assurance plan. Process records for the nuclear fuel are also maintained under the NRC-approved quality assurance plan" (SAR at 1.5.1-5). Lack of physical inspection is explained by the statement that "DOE has no regulatory authority at the purchasers' sites . . . DOE does not currently intend to witness canister and cask loading activities on a routine basis." *Id*.

This DOE position was made lucidly clear by DOE's Christopher Kouts, under questioning by NWTRB member Dr. David Duquette at the NWTRB's Winter Board Meeting (01/24/2007), LSN# NEV000003412:

> Q: Do you anticipate doing the seal welding and inspection of the seal welds [of the TAD] on site at the utilities before transportation occurs?
>
> A: The seal welding will be done for the purposes of the TAD at the reactor sites. The seal welding for the waste package will be done at the repository. And in terms of our need to inspect or be there to do that, we have, as I said before, we have no regulatory authority over the utility industry in any manner. I think that's overseen by the NRC. All of them have qualified QA programs. But that's an issue that we're going to have to address as we move forward.

Id. at 191-92.

Kouts went on to promise that:

> [T]here will be a significant certification on the part of the utility to indicate to us that they have met our requirements, and we're going to have to make sure before we accept that TAD for transport to the repository that it does meet all our requirements. You know, that certification, again, hasn't been determined exactly how we're going to do that, but that's something that we're going to require before we accept these things.

Id. at 192. Unfortunately, DOE proceeded to submit its License Application to NRC without ever dealing with that issue or resolving the manner in which DOE would assure that the QA applied by the nuclear utilities preparing and packing the TAD with nuclear waste would be sufficient to DOE's needs. DOE has never secured the contractual agreement Kouts acknowledged was prerequisite to requiring such compliance on the part of the utilities.

Recognizing that a small number of TAD containers will be loaded by DOE at the repository (with DOE estimating 90 percent, however, to be loaded by utilities at the reactor sites), it is stunning to read the dichotomy between DOE's plan to assure that foreign matter does not enter the TADs **which DOE loads** at the repository, with the comparative lack of control of that very important issue with respect to TADs **loaded by the utilities** at the nuclear sites. Thus, DOE explains:

> At the GROA, the procedures for TAD canister loading and canister transfer procedures will specifically identify the items that are allowed to be placed inside a TAD canister or waste package. The procedures will also identify steps to exclude foreign material. The loading plans prepared before a particular waste package or TAD canister is loaded will uniquely identify the items to be placed in the waste package or TAD canister by the canister, TAD canister, or commercial assembly unique identifiers. Controls and accountability logs combined with close-out inspections, as appropriate, will be established to limit unauthorized materials entry into the canister or waste package.

SAR Subsection 1.5.1.1.1.2.5.1 and Table 1.5.1-8 at 1.5.1-111. By comparison, DOE has **no plan** to preclude introduction of foreign materials into canisters loaded at utility sites: "Loading of the TAD canister at off-GROA locations will be controlled by the certificate of compliance issued by the NRC as part of the TAD certification for 10 C.F.R. Part 71 and 10 C.F.R. Part 72" (*see* Table 1.5.1-8 at 1.5.1-111) (which certification has merely to do with the adequacy of the empty TAD canister as produced at the factory; the NRC certification has nothing at all to do with proof of the implementation by the utility of a compliant QA program and safe loading and sealing of the TADs). NRC has specifically disavowed undertaking any such responsibility and has specifically confronted DOE on this issue. In an August 10, 2006 letter to DOE (LSN# NRC000028424 at 2, 3), NRC warned DOE:

> DOE needs to implement QA requirements consistent with the safety significance of the TAD canisters and their internal materials and components (*e.g.*, CSNF cladding). The need and methods for assurance or verification of TAD canister components and material compliance with the DOE specifications and CSNF Waste Acceptance Criteria are also important. These include the QA program processes and methods for requiring and implementing technical and QA program requirements for the entities that provide and load the TAD canisters, and the DOE QA program oversight, verification, and receipt inspection.

In spite of the clearly stated expectation of the NRC, DOE subsequently commented, at a December 7, 2006 NRC Management Meeting (LSN# NRC000028883 at 9), that utilities using the TAD will be required to certify to DOE that the canister has been loaded and prepared in accordance with the provisions of an approved QA program and DOE specifications, but that "DOE asserts NO regulatory authority over utility operations" (*id.*) (emphasis in original).

NRC again wrote to DOE on March 23, 2007 (LSN# NRC000029080 at 1) , in order to make it lucidly clear that DOE had the responsibility for oversight of TAD canister loading at the utility sites, stating:

> As stated in our letter dated August 10, 2006, Quality Assurance (QA) requirements are an important part of 10 CFR Part 50, and Parts 71, 72, and 63. Under Part 63, for example, DOE should implement the QA requirements consistent with the significance, for safety and waste isolation, of the TAD canister, for use at a geologic repository. These include the QA program processes and methods for oversight and verification of activities by entities that provide and load TAD canisters, and for receipt inspection of TAD canisters at a potential repository at Yucca Mountain, NV.

In a June 8, 2007 response (LSN# NRC000029223 at 1), DOE simply tried to change the subject, focusing on the issue of its TAD "Performance Specification," stating:

> A justification or basis is not appropriate for inclusion in this specification, as that is not the purpose of the performance specification. However, appropriate justification will be provided in DOE's forthcoming LA. This includes the NRC comment provided in the cover letter related to the implementation of quality assurance program processes and methods for oversight and verification of loading at reactor sites.

In its LA, however, DOE continued to eschew any such responsibility, *see supra*. Accordingly, the introduction of the proposed TAD to the proposed Yucca repository site presents an enormous risk of adverse consequences to workers and the public.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsections 5.0, 5.1, 1.5, 1.5.1, 1.2.1, and similar subsections, and DOE'S QARD (incorporated by reference in the License Application in Chapter 5) Sections 7.1, 7.2, and similar subsections, which demonstrate that DOE is required to, but does not intend to, require certainty with respect to the contents and proper packaging of those contents by nuclear utilities providing waste to DOE for the proposed repository in transportation, aging, and disposal (TAD) canisters. DOE's LA submission demonstrates a complete quality assurance failure with respect to the important-to-safety (ITS) TAD and renders the TAD unusable for emplacement and storage of waste in the proposed Yucca Mountain repository.

NEV-SAFETY-173 - EMPLACEMENT DRIFT MONITORING

1. A statement of the contention itself

SAR Subsection 1.3.4.8.2.4 and similar subsections, which discuss monitoring processes for waste emplacement and the pre-closure period in general, fail to include sufficient detail to determine whether these monitoring efforts will fulfill the requirements that the LA places on them, and as a result, the LA assumptions related to waste package emplacement and the effectiveness of the engineered barrier system are unfounded.

2. A brief summary of the basis for the contention

The LA assumes that the waste packages and other engineered barriers are installed within specified tolerances and in conformance with other engineering requirements and that the ventilation system will maintain the temperature at a level that will facilitate installation of the drip shields or retrieval of the waste packages. However, the lack of information on the systems for monitoring the conditions in the emplacement drifts during the pre-closure period means that there is no assurance that these assumptions can be achieved.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy

the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(9) requires an assessment to determine the degree to which those features, events and processes of the site that are expected to materially affect compliance with Section 63.113 have been characterized, and paragraph (c)(15) requires an explanation of measures used to support the models used to provide the information required in paragraph (c)(9). 10 C.F.R. § 63.114 (part of Subpart E) requires a performance assessment to be completed to evaluate the ability of the engineered barrier system along with natural barriers to meet the performance objectives of Section 63.113. 10 C.F.R. § 63.114(a) requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.3.4.8.2.4 at 1.3.4-37 discusses the cameras mounted on the TEV for remote monitoring of the placement of the waste packages. However, no further details on the cameras or their locations on the TEV are provided. No details are provided on how conditions would be monitored after emplacement within a drift has been completed but before installation of the drip shields has commenced.

SAR Subsection 1.3.5.2 at 1.3.5-15 through 1.3.5-17, which discusses operational processes and procedures for the ventilation system, states that instrumentation will be provided for remotely monitoring airflow volumes and temperatures in the emplacement drifts, airflow regulator damper positions, and other features of the ventilation system. However, no details are provided on the instruments to be used to accomplish this monitoring. Similarly, there is no mention of monitoring of radiation levels, which could signal whether a waste package breach had occurred.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 1.3.4.8.2.4 and similar subsections, which discuss monitoring processes for waste emplacement and the pre-closure period in general, because they fail to include sufficient detail to determine whether these monitoring efforts will fulfill the requirements that the LA places on them, and as a result, the LA assumptions related to waste package emplacement and the effectiveness of the engineered barrier system are unfounded. These LA assumptions are fundamental to the post-closure safety analysis. Thus, by failing to address these considerations, SAR Subsection 1.3.4.8.2.4 and similar subsections fail to comply with 10 C.F.R. § 63.114(a) which requires the inclusion of information on the design of the engineered barrier system used to define parameters and conceptual models used in the assessment.

(3) Pre-Closure Safety (Including Terrorism Risks)

(a) Aircraft Crash

NEV-SAFETY-174 - CONTROLS AND RESTRICTIONS

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections, which screen-out aircraft crashes at the Yucca Mountain repository, fail to provide any documentary evidence of any procedural controls for monitoring flight activity over the proposed flight restricted airspace with the United States military, and if no such controls exist then the crash of military aircraft at the repository should have been evaluated in terms of doses to the public and workers.

2. A brief summary of the basis for the contention

DOE has not developed any mechanism for controlling or monitoring the number of flights over the proposed flight restricted airspace, and DOE has the burden of proving that such controls are in place.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or

performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1, and related subsections, and "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, specify that a flight restricted airspace with many operational controls exists as well as claiming the ability to monitor the number of over flights of the proposed restricted airspace.

DOE has the burden of proving that such controls exist and are an effective means of both monitoring and controlling the number of flights over the proposed flight restricted airspace. Notwithstanding DOE's commitment to implement procedural controls, DOE fails to describe in any detail the nature of the procedural controls and fails to explain the mechanism that would be utilized to monitor the proposed prohibition. In order to take advantage of any such procedural controls, DOE has the burden not only to identify the controls with sufficient specificity, but more importantly to prove the controls are currently in effect and operating, or will be put in place and how they will operate. DOE cannot take credit for as yet unidentified procedural controls to control or monitor aircraft activity over the proposed flight restricted airspace.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the DOE statement in SAR Subsection 1.6.3.4.1 and related subsections, which in turn relies on DOE reference document DN2002488951, that flights over the Yucca Mountain repository will be effectively controlled or monitored. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error, it does not include information on the crash of military aircraft at the Yucca Mountain repository, and it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such a crash. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-175 - CONTROLS ON PILOT RELIEF

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections, which screens-out aircraft crashes at the Yucca Mountain repository, fails to provide any documentary evidence of any procedural controls for restricting pilots from using a pilot relief "piddle pack" when operating aircraft over the proposed flight restricted airspace, and if none exists then the crash of military aircraft at the repository should have been evaluated in terms of doses to the public and workers.

2. A brief summary of the basis for the contention

DOE has not developed any mechanism for restricting pilots from using a pilot relief device known as a piddle pack over the proposed flight restricted airspace or monitoring the same pilot activity when flying, and DOE has the burden of proving that such controls are in place.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include

information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1, and related subsections, and "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, specify that a flight restricted airspace with many operational controls exists as well as claiming the ability to monitor the number of over flights of the proposed restricted airspace. One of the specific controls is the restriction of pilots from using a piddle pack, a pilot relief device that allows pilot to urinate during a flight. DOE further defines the use of a piddle pack as a "special activity for personal comfort," and therefore prohibits pilots from using such item.

Fighter pilots routinely use piddle packs as a means of personal physical relief during flight operations. Using a piddle pack is similar to a pilot replacing wet gloves in flight for dry gloves or cleaning eye glasses. Currently there are no rules prohibiting any of these three activities in flight and yet DOE states that a restriction is in place. The rules that govern pilot activity while flying are not controlled by DOE, but by the military services ("U.S. Air Force Multi-Command Instruction 11-F-16 Volume 3, Virtual Pilot Operational Procedures – F-16"

(3/10/2006), LSN# NEV000005429). DOE can not impose such rules on the military services and yet takes credit for doing so.

DOE has the burden of proving that such controls exist and are an effective means of both monitoring and controlling the restriction placed on the pilots over the proposed flight restricted airspace. Notwithstanding DOE's commitment to implement procedural controls, DOE fails to describe in any detail the nature of the procedural controls and fails to explain the mechanism that would be utilized to monitor the proposed prohibition. In order to take advantage of any such procedural controls, DOE has the burden not only to identify the controls with sufficient specificity, but more importantly to prove the controls are currently in effect and operating, or will be put in place and how they will operate. DOE cannot take credit for as yet unidentified procedural controls to control or monitor aircraft activity over the proposed flight restricted airspace.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the DOE statement in SAR Subsection 1.6.3.4.1, and related subsections, which in turn relies on DOE reference document DN2002488951, that flights over the Yucca Mountain repository will be effectively controlled or monitored. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error, it does not include information on the crash of military aircraft at the Yucca Mountain repository, and it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such a crash. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-176 - CONTROLS ON PILOT MANEUVERING

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections, which screen-out aircraft crashes at the Yucca Mountain repository, fail to provide any documentary evidence of any procedural controls for restricting pilots from maneuvering their aircraft when operating over the proposed flight restricted airspace, and if none exists then the crash of military aircraft at the repository should have been evaluated in terms of doses to the public and workers.

2. A brief summary of the basis for the contention

DOE has not developed any mechanism for restricting pilots from maneuvering their aircraft over the proposed flight restricted airspace, or monitoring the same pilot activity when flying and DOE has the burden of proving that such controls are in place.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or

performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and § 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1 at 1.6-22 states that pilots over the Nevada Test Site or the Nevada Test and Training Range will be prohibited from maneuvering their aircraft. As the only support for this assertion, the SAR references "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, which merely reiterates the prohibition in Section 7, at 75. Nonetheless, DOE took credit for this prohibition in analyzing the potential aircraft hazards at the Yucca Mountain repository, and screened-out aircraft crashes from consideration as a result. *See* SAR Subsection 1.6.3.4 and Table 1.6-2. DOE also committed to implement a procedural control in order to ensure the prohibition is implemented. *See* SAR Table 1.9-10 (PSC-17), and Subsection 5.8.3. SEIS Figure 3-1 at 3-6 illustrates that the Nevada Test and Training Range (NTTR) abuts the Yucca Mountain site to the immediate north.

Additionally DOE has not established any criteria for what constitutes "aircraft maneuvering" parameters. Until such criteria are established, monitoring and controlling them is not possible.

DOE has the burden of proving that there is an agreement with the U.S. military to prohibit certain operational activities of military aircraft flying anywhere near the Yucca Mountain repository. The United States Air Force has made clear that over 75 percent of all USAF stateside live munitions are employed at the NTTR, and that testing and training is occurring on increasingly sophisticated weaponry. *See* Letter from J. Jumper, USAF Chief of Staff, and J. Roche, Secretary of the Air Force to Hon. Duncan Hunter, Chairman, Committee on Armed Services, U.S. House of Representatives (9/11/2003), LSN# DN2001403483 at 1. In addition, the Nellis range complex consists of extensive air and ground working areas, live ordnance impact areas, and an extensive array of instrumented threat simulators whose synergistic effect is to create a high fidelity air combat environment which is used for both training and testing. *See* Letter from the Secretary of the Air Force to Hon. Don Young, Chairman, Committee in Resources, U.S. House of Representatives (9/20/1995), LSN# DEN000357493 at 1. Given these assertions, there is no likelihood that the U.S. military would agree to a prohibition on carrying live ordnance or using electronic jamming when operating in the airspace above the Yucca Mountain repository. Therefore, one of the key premises for DOE screening-out military aircraft crashes from consideration at the Yucca Mountain repository is in error. DOE has the burden of proving that the USAF has agreed or will agree to its proposed prohibitions on operational activities, and failing such proof DOE must analyze crashes of military aircraft at the Yucca Mountain repository.

Notwithstanding DOE's commitment to implement procedural controls, as noted above, DOE fails to provide any criteria to define what constitutes aircraft maneuvering parameters. Additionally, DOE also fails to describe in any detail the nature of the procedural controls and furthermore fails to explain the mechanism that would be utilized to monitor the proposed prohibition. In order to take advantage of any such procedural controls, DOE has the burden not only to identify the controls with sufficient specificity, but more importantly to prove the controls are currently in effect and operating, or will be put in place and how they will operate. DOE cannot take credit for as yet unidentified procedural controls to prohibit aircraft maneuvering over Yucca Mountain when such prohibitions do not exist and no provision is in place for their implementation. In addition, DOE cannot presume that it will obtain the agreement of third parties, *e.g.*, the United States Air Force, to comply with such procedural controls when in fact the USAF has declined to do so.

Given the nature of the activities performed by the United States Air Force at the NTTR, the maneuvering of aircraft is normal and typical. Moreover, such activities are governed by military operations manuals, not airspace considerations. *See* "U.S. Air Force Multi-Command Instruction 11-F-16 Volume 3, Virtual Pilot Operational Procedures – F-16" (3/10/2006), LSN# NEV000005429. Therefore, any efforts to prohibit the aircraft maneuvering would require the inclusion of such prohibitions in military operations manuals, and currently the military operations manuals do not include such restrictions. In addition, DOE cannot presume that it will obtain the agreement of third parties, *e.g.*, the United States Air Force, to modify its military operations manuals to include such restrictions when in fact the USAF has declined to do so.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the DOE statement in SAR Subsection 1.6.3.4.1 and related subsections, which in turn relies on DOE reference document DN2002488951, that flights over the Yucca Mountain repository will be effectively controlled and monitored. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error, it does not include information on the crash of military aircraft at the

Yucca Mountain repository, and it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such a crash. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-177 - CONTROLS ON HELICOPTERS

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections, which screen-out aircraft crashes at the Yucca Mountain repository, fail to provide any documentary evidence of any procedural controls for prohibiting helicopter flights within 0.5 miles of the surface facilities that handle spent nuclear fuel and high level radioactive waste, and if none exist then the crash of military aircraft at the repository should have been evaluated in terms of doses to the public and workers.

2. A brief summary of the basis for the contention.

DOE has not developed any control mechanism for prohibiting helicopter flights within 0.5 miles of the surface facilities that handle spent nuclear fuel and high level radioactive waste, or monitoring the same helicopter flight activity when flying, and DOE has the burden of proving that such controls are in place.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include

information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1, and related subsections, and "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, specify that a flight restricted airspace with many operational controls exists as well as the ability to monitor the number of over flights of the proposed restricted airspace. One of the specific controls is the prohibition of helicopter flights within 0.5 miles of the surface facilities that handle spent nuclear fuel and high level radioactive waste.

SAR Subsection 1.6.3.4.1 at 1.6-22 states that pilots over the Nevada Test Site or the Nevada Test and Training Range will be prohibited from flying within 0.5 miles from essentially all facilities that house high level radioactive waste. As the only support for this assertion, the SAR references DN2002488951, which merely reiterates the prohibition in Section 7 at 75. Nonetheless, DOE took credit for this prohibition in analyzing the potential aircraft hazards at the Yucca Mountain repository, and screened-out aircraft crashes from consideration as a result. *See* SAR Subsection 1.6.3.4 and Table 1.6-2. DOE also committed to implement a procedural control in order to ensure that the prohibition is implemented. *See* SAR Table 1.9-10 (PSC-17), and Subsection 5.8.3. SEIS Figure 3-1 at 3-6 illustrates that the Nevada Test and Training Range (NTTR) abuts the Yucca Mountain site to the immediate north.

DOE has the burden of proving that there is an agreement with the U.S. military to prohibit certain operational activities of military aircraft flying anywhere near the Yucca Mountain repository. The United States Air Force has made clear that over 75 percent of all USAF stateside live munitions are employed at the NTTR, and that testing and training is occurring on increasingly sophisticated weaponry. *See* Letter from J. Jumper, USAF Chief of Staff, and J. Roche, Secretary of the Air Force to Hon. Duncan Hunter, Chairman, Committee on Armed Services, U.S. House of Representatives (9/11/2003), LSN# DN2001403483 at 1. In addition, the Nellis range complex consists of extensive air and ground working areas, live ordnance impact areas, and an extensive array of instrumented threat simulators whose synergistic effect is to create a high fidelity air combat environment which is used for both training and testing. *See* Letter from the Secretary of the Air Force to Hon. Don Young, Chairman, Committee in Resources, U.S. House of Representatives (9/20/1995), LSN# DEN000357493 at 1. Given these assertions, there is no likelihood that the U.S. military would agree to such proposed flight restrictions at the Yucca Mountain repository. Therefore, one of the key premises for DOE screening-out military aircraft crashes from consideration at the Yucca Mountain repository is in error. DOE has the burden of proving that the USAF has agreed or will agree to its proposed prohibition on operational activities, and failing such proof DOE must analyze crashes of military aircraft at the Yucca Mountain repository.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the DOE statement in SAR Subsection 1.6.3.4.1 and related subsections, which in turn relies on DOE reference document DN2002488951, that flights over the Yucca Mountain repository will be effectively controlled and monitored. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error, it does not include information on the crash of military aircraft at the Yucca Mountain repository, and it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such a crash. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-178 - BASIS FOR AIRCRAFT EXCLUSIONS

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections erroneously screen-out aircraft crashes at the Yucca Mountain repository because they inappropriately exclude numerous relevant aircraft crashes from consideration when performing aircraft crash frequency calculations.

2. A brief summary of the basis for the contention

DOE erroneously excludes numerous relevant aircraft crashes from consideration because of unknown distances to the crash, ejection altitudes and glide angles when performing aircraft crash frequency calculations.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository

operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1 and related subsections bases its argument for screening on a crash frequency analysis that was undertaken by DOE that excluded numerous crashes on subjective grounds. There are numerous aircraft crashes reported in the underlying database that are missing valuable information concerning, for example, aircraft altitude, speed, flight path angle, and glide distance, and DOE excluded this information from consideration because it was missing rather than assessing their relevance in the context of Yucca Mountain.

DOE is required to consider the effects of aircraft crashes and to ensure that any assumptions used in the calculations are conservative. *See* "DOE Standard Accident Analysis for Aircraft Crash into Hazardous Facilities," DOE-STD-3014-96 (10/01/1996), LSN# DN2002431791 at 5. NRC applicants, including DOE, are required to consider all aircraft activity in or near any nuclear facility. *Id*. at 39-40. DOE adopted the ACRAM standard as the "approach for performing a *conservative* analysis of the risk posed by a release of hazardous radioactive or chemical material resulting from an aircraft crash into a facility containing significant quantities of such material." *Id*. at 5, emphasis added. The ACRAM model requires the inclusion of all aircraft activity that could imply a risk, uses historical flight activity as a basis for calculating a risk factor, and requires a conservative approach to risk to ensure a higher margin of safety.

DOE failed to fulfill its obligation to use the relevant data and instead screened out many accidents from consideration during their analysis. As a result, the crash factor as determined by DOE substantially underestimates the aircraft crash frequency.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the DOE crash frequency analysis described in SAR Subsection 1.6.3.4.1 and related subsections on the grounds of inappropriate exclusion of relevant crashes from consideration. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of the full range of crashes of relevance. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-179 - CONTROLS ON AIRCRAFT OPERATIONS (MID-AIR)

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections erroneously screen out aircraft crashes at the Yucca Mountain repository using an analysis that is based on the claim that all mid-air collisions and controlled flight into terrain occur during maneuvering, which is not supported by any documentary evidence. Since DOE further claims that maneuvering is prohibited in the airspace over the proposed flight restricted area, these types of accidents have been improperly excluded from the crash frequency analysis.

2. A brief summary of the basis for the contention

DOE claims that all mid air collisions and controlled flight into terrain occur during maneuvering, but fails to provide any documentary evidence supporting this claim. In fact, this claim is false as there are several cases of fighter aircraft involved in mid-air collisions that did not include any high performance maneuvering but rather involved the run over of another aircraft during a typical in-flight rejoin activity when both aircraft were in stable and unaccelerated flight.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain.

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials.

DOE claims in SAR Subsection 1.6.3.4.1 and related subsections that all mid-air collisions and controlled flight into terrain occur during maneuvering. The claim is false. There are several cases of fighter aircraft participating in mid-air collisions that involved no high performance maneuvering, but one aircraft simply ran over of another flight member during a routine in-flight visual rejoin when both aircraft were in normal flight. *See, e.g.*, AFR 110-14, USAF Accident Investigation Report on 16 Sept 1997 mid air collision between F-16A & F-16B aircraft (*see* "Excerpts from Miscellaneous Aircraft Flight Mishap Reports in 1997" (12/31/1997), LSN# DEN001605889 at 48-57; and "AFI 51-503 Accident Investigation Board" (11/11/1997), LSN# NEV000005461, all); and AFR 110-14, USAF Accident Investigation Report on 23 June 1993 mid air collision between F-16C & F-16D aircraft (*see* "Excerpts from

Miscellaneous Aircraft Flight Mishap Reports in 1993" (12/31/1993), LSN# DEN001605244 at 35-37; and "AFR 110-14 USAF Aircraft Accident Investigation" (09/01/1993), LSN# NEV000005482, all); and AFR 110-14 USAF Accident Investigation Report on 22 Oct 1998 mid air collision between F-16C & F-16c aircraft (*see* "Excerpts from Miscellaneous Aircraft Flight Mishap Reports in 1998" (12/31/1998), LSN# DEN001605232 at 45, 47; and "Aircraft Accident Investigation Report: F-16CG, Serial Number 88-0414" (12/12/1998), LSN# NEV000005483, all). Since the flight parameters that characterize maneuvering are not specified by DOE, it is not possible to determine whether DOE has adopted an inappropriate and unduly broad definition of maneuvering as a basis for its statement. Additionally, DOE assumes that the flight restricted airspace is a non-maneuvering area, which is false.

DOE has the burden of proving that the analysis is accurate, complete and conservative. The claims about mid-air maneuvering and controlled flight into terrain are neither accurate nor conservative. The statement that flight over the proposed flight restricted area is non-maneuvering is not factual and is also not conservative. DOE cannot take credit for either claim in its crash frequency analysis.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>.

This contention challenges SAR Subsection 1.6.3.4.1 and related subsections, in which DOE bases its analysis on the claim that all mid-air collisions and controlled flight into terrain occur during maneuvering. This claim is false, as there are several cases of fighter aircraft participating in mid-air collisions that involved no high performance maneuvering but simply the run over of another flight member during a typical in-flight rejoin when both aircraft were in stable and unaccelerated flight. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-180 - CRASH FREQUENCY OF FIXED-WING AIRCRAFT

1. A statement of the contention itself

SAR Subsection 1.6.3.4 and similar subsections, which state that aircraft impact was screened out as an external initiating event, refer to inappropriate calculations as a basis for the screening, making the associated screening decision unjustified.

2. A brief summary of the basis for the contention

The methodology used to characterize the frequency of impacts of fixed-wing aircraft on the repository is inadequately described, has not been demonstrated to be mathematically correct and uses an unnecessary and unjustified approximation in the calculations.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository

operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4 at 1.6-20 states that various external hazards initiating events are screened from consideration. These screened events include aircraft crash. The associated justification is given in SAR Table 1.6-2 at 1.6-50, where the basis is that the chance of an aircraft crash occurring at the repository over the pre-closure period is less than 1 in 10,000. More details of the screening analysis are given in SAR Subsection 1.6.3.4.1. This references the initial evaluation of the aircraft hazard in "Identification of Aircraft Hazards, 000-30R-WHS0-00100-000-008" (7/1/2007), LSN# DN2002481667. That initial evaluation identified the following potential aircraft hazards for further consideration in the second stage of the aircraft hazard evaluation: helicopters; small military aircraft in the Nevada Test Site and Nevada Test and Training Range within 30 miles of the North Portal; and aircraft in public airspace in the Beatty Corridor.

The second stage of the analysis is reported in "Frequency Analysis of Aircraft Hazards for License Application, 000-00C-WHS0-00200-000-00F" (9/24/2007), LSN# DEN001574741. This contention challenges aspects of the computational approach adopted in DEN001574741; specifically, Subsection 4.3.2 at 52 through 59, which describes the methodology for allowing for over-flights of the flight-restricted airspace by fixed-wing aircraft. This description of the methodology is extremely obscure and has not been justified mathematically. Furthermore, it involves an approximation of the calculations, as illustrated in DEN001574741, Figure 4, at 55, which has not been demonstrated to be accurate. A full analysis of the problem has been set out in Thorne, M.C., "Aircraft Crash Analysis: Part 2, Memorandum to H. Horstman" (08/28/2008), and supplementary information giving an analysis of an appropriate probability density function for glide ratios is provided in Thorne, M.C., "Aircraft Crash Analysis: Part 1, Memorandum to H. Horstman" (08/26/2008), and Thorne, M.C., "Aircraft Crash Analysis: Part 3, Memorandum to H. Horstman" (09/03/2008), LSN# NEV000005502, NEV000005506, NEV000005509, NEV000005501 (Glide Ratios), and NEV000005507 (Aligned Flight Directions). It is contended that DEN001574741, Subsection 4.3.2, at 52 through 59 is incomplete and inadequate because it fails to set out an appropriate basis for the calculations of frequencies of crashes of fixed-wing aircraft. It is further contended that a comprehensive analysis of the problem would have eliminated the need to make the approximation shown in DEN001574741, Figure 4. The inadequate basis of analysis presented means that the screening decision that has been made has not been justified.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 1.6.3.4 and similar subsections, which state that aircraft impact was screened out as an external initiating event, because they refer to inappropriate calculations as a basis for the screening, making the associated screening decision unjustified. Thus, the LA does not comply with 10 C.F.R. § 63.112(b), which requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. As relevant event sequences have been inappropriately screened from consideration, the pre-closure safety analysis does not include either a systematic analysis of all relevant human-induced hazards or an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of one such hazard, i.e. aircraft impact.

NEV-SAFETY-181 - BASIS FOR CRASH DENSITY CALCULATIONS

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections incorrectly assumes that the crash initiation density of military aircraft outside the proposed flight restricted airspace is independent of the number of sorties flown each year and will not change if the number of sorties increases, and therefore incorrectly calculates the crash initiation frequency resulting in an understatement of risk of a military aircraft crash at the repository and an inappropriate screening of aircraft crashes from consideration.

2. A brief summary of the basis for the contention

DOE incorrectly assumes that the crash initiation density of military aircraft outside the proposed flight restricted airspace is independent of the number of sorties flown each year and will not change if the number of sorties increases. However, the crash initiation rates outside the proposed flight restricted airspace are based on historical crash rate data provided by the United States Air Force. These crash rates are presented as the rate of crashes per flight. The calculated crash initiation density is directly proportional to the number of flights in the airspace in question.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials

described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1 at 1.6-22, and "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, state that the aircraft analysis conservatively evaluates three contributors to the overall probability of an aircraft impact. However, DOE fails to conservatively evaluate military crash initiation events in the area outside the proposed flight restricted airspace.

The crash initiation rates outside the proposed flight restricted airspace are based on data provided by the United States Air Force and are based on the historical crash rates of each type of aircraft that will fly over or near the repository. The crash rates provided by the military are presented as a rate of crashes per flight. The crash rates provided by the Air Force are just that, crash *rates*. The calculated crash density is directly proportional to the number of flights in the airspace in question. Thus, if the number of flights doubles then the number of crashes is expected to double.

DOE assumes that the crash density outside the proposed flight restricted airspace is independent of the number of sorties flown annually. DOE failed to provide any justification for this assumption. DOE has the burden of proving their assumption is true and until this is accomplished, they cannot take credit for it in their crash frequency analysis.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's screening judgment contained in SAR Subsection 1.6.3.4.1, which in turn relies on DOE reference document DN2002488951, which includes the erroneous statement that the aircraft analysis conservatively evaluates three contributors to the overall probability of an aircraft impact. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error. The resultant screening of aircraft crashes in SAR Subsection 1.6.3.4.1 means that the LA does not include information on the crash of military aircraft at the Yucca Mountain repository, and it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such crashes. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-182 - GLIDE DISTANCE

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 and related subsections depends on the assumption that for flights that are outside the flight restricted airspace the ejection as a result of a crash initiating event that results in a crash occurs before the aircraft enters the flight restricted airspace, but fails to provide any documentary evidence justifying the assumption and fails to consider the frequency of impacts on the facility from aircraft accidents that are initiated outside the flight restricted airspace, leading to an inappropriate screening of aircraft crashes from consideration.

2. A brief summary of the basis for the contention

DOE assumes that aircraft can not glide into the proposed flight restricted airspace with the pilot in the aircraft and that the pilot will eject before entering that airspace. Additionally, DOE incorrectly uses the distance that aircraft travels after ejection for risk calculations instead of the distance traveled after the initiating event of the crash. DOE is thus effectively screening out *the majority* of aircraft crashes outside the flight restricted airspace without documentary evidence or justification.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety

of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1 and related subsections, and DOE reference document "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, indicates that in aircraft crashes that are initiated outside the proposed flight restricted airspace, the pilot will eject from the aircraft before entering the flight restricted airspace. This statement is false, and therefore, the resultant aircraft crash frequency calculations are in error. DOE incorrectly assumes that the crash initiating event is the pilot ejection. The crash initiating event is defined as the event that ultimately causes an aircraft to crash, not the pilot ejection.

In the case of an F-16, the majority of crashes are caused by engine failure. When an F-16 engine fails, by procedure, the pilot performs emergency checklists and, time permitting, attempts to restart the engine. These actions take time and this translates to additional distance being flown by the pilot until the engine restarts or the pilot ejects and the aircraft subsequently impacts the ground. Depending on the aircraft speed and altitude, the time and distance covered between the initiating event and the pilot ejection can be in excess of several minutes and over 20 miles. Under these circumstances, the pilot is in control of the aircraft and will continue to attempt to restart the engine until a predetermined altitude near the ground. When the pilot subsequently ejects from the aircraft, it will fly a very small distance to ground impact relative to the total distance flown from the initiating event.

DOE assumes for the purposes of risk calculations that aircraft cannot glide into the proposed flight restricted airspace with the pilot in the aircraft and that the pilot will eject before entering the same airspace. Additionally, DOE incorrectly uses the distance that aircraft travels after ejection for risk calculations instead of the distance traveled after the initiating event of the crash. DOE is thus effectively screening out *the majority* of aircraft crashes initiated outside the flight restricted airspace without documentary evidence or justification.

Based on this assumption, SAR Subsection 1.6.3.4.1 at 1.6-22, which states that "[t]he aircraft analysis conservatively evaluates three contributors to the overall probability of an aircraft impact" is not supported. DOE has the burden of proving their assumption is true. Until DOE proves its assumption they cannot take credit for it in their crash frequency analysis. Thus, the screening of aircraft crashes from the assessment has not been justified.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the DOE statement in SAR Subsection 1.6.3.4.1, which in turn relies on DOE reference document DN2002488951, that the aircraft analysis conservatively evaluates three contributors to the overall probability of an aircraft impact. As a result, SAR

Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error. The resultant screening of aircraft crashes in SAR Subsection 1.6.3.4.1 means that the LA does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such crashes. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-183 - CRASH RATES

1. A statement of the contention itself

SAR Subsection 1.6.3.4.1 relies on an analysis that assumes that the crash rate of 2.74×10^{-8} for military overflights of the flight restricted airspace is the updated F-16 accident rate for normal in-flight mode, but fails to provide any documentary evidence that this crash rate is appropriate, meaning that the associated screening decision cannot be justified.

2. A brief summary of the basis for the contention

The crash rate of 2.74×10^{-8} for military overflights of the flight restricted airspace is defined as the updated F-16 accident rate for normal in-flight mode, but the failure to provide any documentary evidence that this crash rate is justified means that the higher crash rate for "special" flight mode for F-16 aircraft must be used.

3. Demonstration that the contention is within the scope of the hearing

This contention raises an issue whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design to comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(1) requires the safety analysis report to include information regarding events outside of the site that is relevant and material to the safety or

performance of the geologic repository. 10 C.F.R. §§ 63.102(f) and 63.111(c) (both part of Subpart E) requires the performance of a pre-closure safety analysis of the geologic repository operations area. 10 C.F.R. § 63.112(b) (part of Subpart E) requires the pre-closure safety analysis to include an identification and systematic analysis of human-induced hazards, and Section 63.112(e)(8) requires an analysis of the ability of structures, systems and components to perform their intended safety function assuming the occurrence of event sequences. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 1.6.3.4.1 and related subsections, and DOE reference document, "Frequency Analysis of Aircraft Hazards for Accident Analysis, Rev. 00F" (9/24/2007), LSN# DN2002488951, assume that the crash rate that should be used as a basis for calculation in the proposed flight restricted airspace is that for a F-16 in a "normal" flight mode. DOE has not justified this assumption as a basis for aircraft crash hazard calculations. Unless DOE justifies a "normal" mode for crash rates, then the historically justified crash rate for "special" flight mode for F-16 aircraft must be used.

There are two cases of F-16 flight activity that need to be examined:

1. Flights entering the airspace from above. The United States Air Force provided crash rates to DOE for various modes of flight to include takeoff and landing, normal, special, *etc.* DOE selected the "normal" rate based on the assumption that maneuvering aircraft are not permitted in the airspace directly above the proposed flight restricted airspace. Unless this assumption is justified, DOE must use the higher special flight mode crash rate for F-16 aircraft.

2. Injured aircraft entering the airspace from the side or above. DOE assumes, without any evidence or justification, that such aircraft outside of the proposed flight restricted airspace cannot enter the restricted airspace.

> DOE assumes that any aircraft experiencing a crash initiating event outside of the airspace will somehow not enter the airspace, from above or from the side of the airspace again without any justification. This assumption ignores the existing rules of flight for aircraft experiencing emergencies and also ignores the longstanding F-16 operating procedures ("U.S. Air Force Multi-Command Instruction 11-F-16 Volume 3, Virtual Pilot Operational Procedures – F-16" (3/10/2006), LSN# NEV000005429). Unless this assumption is justified, the DOE must use the higher "special" flight mode crash rate of the F-16 aircraft and add these types of flight activities into the crash rate calculations.

Based on the assumption of "normal" crash rates, SAR Subsection 1.6.3.4.1 at 1.6-22 states that, "The aircraft analysis conservatively evaluates three contributors to the overall probability of an aircraft impact," but the argument of conservatism is not supported because "special" rather than "normal" crash rates should be used unless DOE can justify the use of "normal" crash rates. Unless DOE proves its assumption, it cannot use the normal mode crash rate for F-16 aircraft in its crash frequency analysis and as a basis for screening aircraft crashes from consideration.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the DOE statement in SAR Subsection 1.6.3.4.1 and related subsections, which in turn relies on DOE reference document DN2002488951, that the aircraft analysis conservatively evaluates three contributors to the overall probability of an aircraft impact. As a result, SAR Subsection 1.6.3.4.1 is both materially incomplete and inaccurate because its assertion is both unsupported and in error. The resultant screening of aircraft crashes in SAR Subsection 1.6.3.4.1 means that the LA does not include all relevant information on the crash of military aircraft at the Yucca Mountain repository, and it does not present the results of a systematic analysis of structures, systems and components at the repository to perform their intended safety function in the event of such crashes. Therefore, SAR Subsection 1.6.3.4.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(1), 63.102(f), 63.111(c), 63.112(b) and 63.112(e)(8), and the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

(b) Land Ownership and Control

NEV-SAFETY-184 - RIGHT-OF-WAY N-48602

1. <u>A statement of the contention itself</u>

Legal issue: SAR Subsection 5.8.1.1, which states that DOE right-of-way N-48602 (expiring in 2014) has been withdrawn from all forms of appropriation under the public laws including mining and geothermal leasing laws, does not properly account for the facts that (a) the right-of-way only provides DOE with the right to perform Yucca Mountain site characterization studies until December 31, 2014, (b) the land associated with the right-of-way is not under the jurisdiction and control of DOE, (c) the land has not been permanently reserved for DOE to construct and operate the Yucca Mountain repository, and (d) the land is not held free and clear of all significant encumbrances.

2. <u>A brief summary of the basis for the contention</u>

Even though right-of-way N-48602 governs 18,700 acres of land, which is closed to public access and use, encompasses a portion of the geologic repository operations area, and lies wholly within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary, it does not authorize DOE to construct and operate the Yucca Mountain repository at any time and it also does not allow for any DOE use of the land after December 31, 2014.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(a)(1) and 63.121(a)(2), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(a)(1) (part of Subpart E) requires the geologic repository operations area to be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. 10 C.F.R. § 63.121(a)(2) requires such lands to be held free and clear of all significant encumbrances including easements for right-of-way. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 5.8.1.1 at 5.8-3 states that the Bureau of Land Management, with the concurrence of the United States Air Force, granted DOE right-of-way N-48602 governing approximately 18,700 acres of land on the Nevada Test and Training Range as depicted on SAR Figure 5.8-1. EIS Subsection 3.1.1.2 at 3-9 states that this land is not available for public access and use. SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that right-of-way N-48602 encompasses a portion of the geologic repository operations area, and the northwestern portion of the surrounding land – all of which fall within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary.

"Right-of-Way Grant N-48602 Issued" (01/02/2008), LSN# DEN001584251 is limited in two particularly significant respects. First, it only provides DOE with the right to perform Yucca Mountain site characterization studies. *Id*. at 1, 5, 7, and 8. Second, it expires on December 31, 2014. *Id*. at 5. As a result, right-of-way N-48602 cannot be utilized to locate a geologic repository operations area for the following reasons.

- The land is not under the jurisdiction and control of DOE (it is owned by the Bureau of Land Management and under the control of the Bureau of Land Management and the United States Air Force) as required by 10 CFR § 63.121(a)(1).
- Since the right-of-way expires on December 31, 2014, the land is not permanently reserved for DOE's use as required by 10 C.F.R. § 63.121(a)(1).
- Since the right-of-way only permits site characterization studies (and not construction or operation of a repository) there is a significant encumbrance on the land that is prohibited by 10 C.F.R. § 63.121(a)(2).

As a result, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2), and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and right of way N-48602 (DEN001584251), which states that right-of-way N-48602 has been withdrawn from all forms of appropriation under the public land laws including mining laws and geothermal leasing laws. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.1.1 is materially incomplete because it fails to acknowledge that right-of-way N-48602 is limited in both duration and scope. Specifically, right-of-way N-48602 terminates on December 31, 2014 and only permits site characterization studies. As a result, SAR Subsection 5.8.1.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2) because DOE does not exercise jurisdiction and control over the geologic repository operations area, the geologic repository operations area has not been permanently withdrawn and reserved for DOE's use, and there is a significant encumbrance on the land underlying the geologic repository operations area. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. §§ 63.31(a)(3).

NEV-SAFETY-185 - RIGHT-OF-WAY N-47748

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.1.1, which states that DOE right-of-way N-47748 (expiring on December 31, 2014) covers public land administered by the Bureau of Land Management, does not properly account for the facts that (a) the right-of-way only provides DOE with the right to perform Yucca Mountain site characterization studies until December 31, 2014, (b) the land associated with the right-of-way is not under the jurisdiction and control of DOE, (c) the land has not been permanently withdrawn from public use, (d) the land has not been permanently reserved for DOE to construct and operate the Yucca Mountain repository, and (e) the land is not held free and clear of all significant encumbrances.

2. A brief summary of the basis for the contention

Even though right-of-way N-47748 governs approximately 51,790 acres of public land, which encompasses a portion of the geologic repository operations area and lies wholly within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary, it permits public access and use, does not authorize DOE to construct and operate the Yucca Mountain repository at any time, and it does not allow for any DOE use of the land after December 31, 2014.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(a)(1) and 63.121(a)(2), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(a)(1) (part of Subpart E) requires the geologic repository operations area to be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for DOE's use. 10 C.F.R. § 63.121(a)(2) requires such lands to be held free and clear of all significant encumbrances including easements for right-of-way. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.8.1.1 at 5.8-3 states that the Bureau of Land Management granted DOE right-of-way N-47748 governing approximately 51,790 acres of public land as depicted on SAR Figure 5.8-1. SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that right-of-way N-47748 encompasses a portion of the geologic repository operations area, and the southwestern portion of the surrounding land – all of which fall within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary.

"Right-of-Way Grant N-47748 Issued" (12/20/2007), LSN# DEN001582273, is limited in two particularly significant respects. First, it only provides DOE with the right to perform Yucca Mountain site characterization studies. *Id.* at 1, 4, 7 and 8. Second, it expires on

December 31, 2014. *Id*. at 5. As a result, right-of-way N-47748 cannot be utilized to locate a geologic repository operations area for the following reasons.

- The land is not under the jurisdiction and control of DOE (it is owned by and under the control of the Bureau of Land Management) as required by 10 C.F.R. § 63.121(a)(1).
- As noted in FEIS Subsections S.5.1.1 at 5-45, 3.1.1.2 at 3-9, and 3.1.1.3 at 3-9, as well as FEIS Figures S17 at S-47, S18 at S-48, and 3-1 at 3-8, the land is available for public use and access, *e.g.*, off-road vehicular activities, and there is a designated utility corridor in the southern portion, and thus contrary to 10 C.F.R. § 63.121(a)(1) the land is not permanently withdrawn.
- The right-of-way expires on December 31, 2014, and therefore the land is not permanently reserved for DOE's use as required by 10 C.F.R. § 63.121(a)(1).
- Since the right-of-way only permits site characterization studies (and not construction or operation of a repository), there is a significant encumbrance on the land that is prohibited by 10 C.F.R. § 63.121(a)(2).

As a result, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2), and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and right of way N-47748 (DEN001582273), which states that right-of-way N-47748 covers public lands administered by the Bureau of Land Management. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.1.1 is materially incomplete because it fails to acknowledge that right-of-way N-47748 is limited in both duration and scope. Specifically, right-of-way N-47748 terminates on December 31, 2014, and only permits site characterization studies. As a result, SAR Subsection 5.8.1.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and

63.121(a)(2) because DOE does not exercise jurisdiction and control over the geologic repository operations area, the geologic repository operations area has not been permanently withdrawn and reserved for DOE's use, and there is a significant encumbrance on the land underlying the geologic repository operations area. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-186 - "RANCH BOUNDARY" LAND

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.1.1, which states that a Memorandum of Agreement governs Yucca Mountain project activities on 58,000 acres of non-public land on the Nevada Test Site (referred to as the Ranch Boundary), does not properly account for the facts that (a) the agreement only provides DOE with the right to perform Yucca Mountain site characterization studies until that right is terminated upon 90 days' written notice, (b) the land associated with the agreement has not been permanently reserved for DOE to construct and operate the Yucca Mountain repository, and (c) the land is not held free and clear of all significant encumbrances.

2. A brief summary of the basis for the contention

Even though the Memorandum of Agreement governs approximately 58,000 acres of non-public land on the Nevada Test Site (referred to as the Ranch Boundary), which encompasses a portion of the geologic repository operations area and lies almost entirely within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary, it does not authorize DOE to construct and operate the Yucca Mountain repository at any time, and it does not allow for any DOE use of the land if terminated upon 90 days' written notice.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(a)(1) and 63.121(a)(2), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(a)(1) (part of Subpart E) requires the geologic repository operations area to be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for DOE's use. 10 C.F.R. § 63.121(a)(2) requires such lands to be held free and clear of all significant encumbrances including rights arising under other real estate documents. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.8.1.1 at 5.8-3 states that a Memorandum of Agreement between the predecessor offices of the DOE National Nuclear Security Agency Nevada Site Office and the DOE Office of Civilian Radioactive Waste Management allows DOE to use approximately 58,000 acres of non-public land on the Nevada Test Site (referred to as the Ranch Boundary) as depicted on SAR Figure 5.8-1. SAR Figures 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that the Ranch Boundary encompasses a portion of the geologic repository operations area and the northeastern and southeastern portion of the surrounding land – almost all of which falls within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary.

The "Memorandum of Agreement (MOA) Between DOE Nevada Operations Office and the Yucca Mountain Site Characterization Office" (09/01/1994), LSN# DEN001585704, is limited in two particularly significant respects. First, it only provides DOE with the right to perform Yucca Mountain site characterization studies. *Id*. at 6-8. Second, the Agreement can be terminated upon 90 days' written notice. *Id*. at 3. As a result, the 1994 Memorandum of Agreement cannot be utilized to locate a geologic repository operations area for the following reasons.

- Since the 1994 Memorandum of Agreement can be terminated upon 90 days' written notice, the land is not permanently reserved for DOE's use as required by 10 C.F.R. § 63.121(a)(1).
- Since the 1994 Memorandum of Agreement only permits site characterization studies (and not construction or operation of a repository) there is a significant encumbrance on the land that is prohibited by 10 C.F.R. § 63.121(a)(2).

As a result, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2), and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and a 1994 Memorandum of Agreement (DEN001585704) which explains that the 1994 Memorandum of Agreement allows DOE to use land on the Nevada Test Site for Yucca Mountain project activities. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.1.1 is both inaccurate and materially incomplete because it fails to acknowledge that the Memorandum of Agreement is limited in both duration and scope. Specifically, the Memorandum of Agreement can be terminated upon 90 days' written notice and only permits site characterization studies. As a result, SAR Subsection 5.8.1.1

does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2) because the geologic repository operations area has not been permanently reserved for DOE's use, and there is a significant encumbrance on the land underlying the geologic repository operations area. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-187 - PUBLIC LAND ORDER 7653

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.1.1, which states that Public Land Order 7653 has withdrawn (for ten years) lands for the evaluation of the potential construction, operation and maintenance of a rail line in the Caliente Rail Corridor, does not properly account for the facts that the land associated with the order (a) is not under the jurisdiction and control of DOE, (b) has not been permanently withdrawn from public use, (c) has not been permanently reserved for DOE to construct and operate the Yucca Mountain repository, and (d) is not held free and clear of all significant encumbrances.

2. A brief summary of the basis for the contention

Even though Public Land Order 7653 governs approximately 308,600 acres of land within the Caliente Rail Corridor, which encompasses a portion of the geologic repository operations area and lies within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary, the public can access the land, the order does not authorize DOE to construct and operate a rail line in the Caliente Rail Corridor at any time, and the order does not allow for any DOE use of the land after December 28, 2015.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(a)(1) and 63.121(a)(2), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(a)(1) (part of Subpart E) requires the geologic repository operations area to be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for DOE's use. 10 C.F.R. § 63.121(a)(2) requires such lands to be held free and clear of all significant encumbrances including easements for right-of-way. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.8.1.1 at 5.8-3 states that the Bureau of Land Management issued Public Land Order 7653 withdrawing land, as depicted on SAR Figure 5.8-1, for 10 years for DOE to evaluate the potential construction, operation and maintenance of a rail line in the Caliente Rail Corridor for transportation of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain repository. SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that lands governed by Public Land Order 7653 lie within the geologic repository operations area and within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary.

Public Land Order 7653 only provides DOE with the right to evaluate approximately 308,600 acres of public land for a rail line to the Yucca Mountain repository until December 28, 2015. *See* "Public Land Order No.7653, Withdrawal of Public Lands for the Department of Energy to Protect the Caliente Rail Corridor; Nevada," 70 Fed. Reg. 76,854 (12/21/2005) at 76,854 (col. 3) and 76,857 (col. 3). As a result, Public Land Order 7653 cannot be utilized to locate a geologic repository operations area for the following reasons.

- The land is not under the jurisdiction and control of DOE (it is owned by and under the control of the Bureau of Land Management) as required by 10 C.F.R. § 63.121(a)(1).
- Since the order applies to public land, the land is not permanently withdrawn contrary to 10 C.F.R. § 63.121(a)(1).
- Since the order expires on December 28, 2015, the land is not permanently reserved for DOE's use as required by 10 C.F.R. § 63.121(a)(1).
- Since the order only permits land evaluation, as opposed to the construction or operation of a repository or a rail line to the repository on the land, there is a significant encumbrance on the land that is prohibited by 10 C.F.R. § 63.121(a)(2).

As a result, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2), and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and reference 70 Fed. Reg. 76,854, regarding the land withdrawal governed by Public Land Order 7653. Specifically, Public Land Order 7653 is limited in both duration (it terminates on December 28, 2015) and scope (it only permits land evaluation, not any construction or operation activities). As a result, SAR Subsection 5.8.1.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2) because DOE does not exercise jurisdiction and control over the geologic repository operations area, the geologic repository operations area has not been permanently withdrawn and reserved for DOE's use, and there is a significant encumbrance on the land underlying the geologic repository operations area. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-188 - PUBLIC LAND ORDER 6802/7534

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.1.1, which states that Public Land Order 6802 (as extended through January 31, 2010 by Public Land Order 7534) withdraws land from the operation of the mining and mineral leasing laws, does not properly account for the facts that the land associated with the orders (a) is not under the jurisdiction and control of DOE, (b) has not been permanently withdrawn from public use, (c) has not been permanently reserved for DOE to construct and operate the Yucca Mountain repository, and (d) is not held free and clear of all significant encumbrances.

2. A brief summary of the basis for the contention

Even though Public Land Order 6802 (as extended by Public Law 7534) governs approximately 4,255.5 acres of land, which encompasses a portion of the geologic repository operations area and lies within the Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary, the public can access the land, the orders do not authorize DOE to construct and operate the Yucca Mountain repository at any time, and the orders do not allow for any DOE use of the land after January 31, 2010.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(a)(1) and 63.121(a)(2), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(a)(1) (part of Subpart E) requires the geologic repository operations area to be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for DOE's use. 10 C.F.R. § 63.121(a)(2) requires such lands to be held free and clear of all significant encumbrances including easements for right-of-way. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.8.1.1 at 5.8-3 states that the Bureau of Land Management issued Public Land Order 6802 (extended by Public Land Order 7534 until January 31, 2010) withdrawing 4255.5 acres of public land, as depicted on SAR Figure 5.8-1, from the operation of the mining and mineral leasing laws. SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that the land governed by Public Land Orders 6802 and 7534 lies within a portion of the geologic repository operations area and wholly within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary.

Public Land Order 6802 and Public Land Order 7534 withdrew 4255.5 acres of public land from mining and mineral leasing laws until January 31, 2010. *See* "Public Land Order

6802, Withdrawal of Public Land to Maintain the Physical Integrity of the Subsurface Environment, Yucca Mountain Project; Nevada" 55 Fed. Reg. 39,152 (09/25/1990) at 39,152 (cols. 2-3); and "Public Land Order No. 7534, Extension of Public Land Order No. 6802; Nevada" 67 Fed. Reg. 53,359 (08/15/2002) at 53,360 (col. 1). As a result, Public Land Orders 6802 and 7653 cannot be utilized to locate a geologic repository operations area for the following reasons.

- The land is not under the jurisdiction and control of DOE (it is owned by and under the control of the Bureau of Land Management) as required by 10 C.F.R. § 63.121(a)(1).
- Since the orders apply to public land, the land is not permanently withdrawn contrary to 10 C.F.R. § 63.121(a)(1).
- Since Public Land Order 7653 expires on January 31, 2010, the land is not permanently reserved for DOE's use as required by 10 C.F.R. § 63.121(a)(1).
- Since the orders only withdraw the land from mining and mineral leasing laws and do not permit the construction or operation of the repository, there is a significant encumbrance on the land that is prohibited by 10 C.F.R. § 63.121(a)(2).

As a result, the LA does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and 63.121(a)(2), and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and references 55 Fed. Reg. 39,152 and 67 Fed. Reg. 53,359, regarding the land withdrawal governed by Public Land Orders 6802 and 7534. Specifically, Public Land Orders 6802 and 7534 are limited both in duration (terminating on January 31, 2010) and scope (only withdrawing land from mining and mineral leasing laws). As a result, SAR Subsection 5.8.1.1 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a)(1) and

63.121(a)(2) because DOE does not exercise jurisdiction and control over the geologic repository operations area, the geologic repository operations area has not been permanently withdrawn and reserved for DOE's use, and there is a significant encumbrance on the land underlying the geologic repository operations area. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-189 - PATENT 27-83-002

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.2.2.1, which concludes that Patent 27-83-002 and the associated rights-of-way N-43366 and NEV 066289 do not present an adverse human action that reduces the ability of the Yucca Mountain repository to isolate waste, does not properly account for the fact that DOE does not exercise any jurisdiction or control over the land on which the patent and rights-of-way have been granted even though the land lies wholly within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary.

2. A brief summary of the basis for the contention

DOE cannot exercise any jurisdiction or control over the land associated with patented mining claim 27-83-002 or rights-of-way N-43366 and NEV 006289 because patented mining claim 27-83-002 (to mine volcanic cinders for use as a raw material in the manufacture of cinder blocks) on 203 acres of land was granted in perpetuity to Hollie O. Allen, right-of-way N-43366 for access to the claim was granted to Hollie O. Allen through at least December 6, 2016, and right-of-way NEV 006289 for a transmission power line was granted in perpetuity to Valley Power Association, Inc., and such claim and rights-of-way apply to land that lies wholly within the Yucca Mountain land withdrawal area boundary and the pre-closure area boundary.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(b) and 63.121(b), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(b) (part of Subpart E) requires DOE to exercise jurisdiction and control over surface and subsurface estates outside the geologic repository operations area, which can include obtaining possessory interests in such estates or withdrawing such estates from patent under general mining laws, as necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. 10 C.F.R. § 63.121(c) requires DOE to exercise jurisdiction and control over activities outside the geologic repository operations area, which can include excluding members of the public, to ensure compliance with radiation exposure and radioactive material release performance objectives identified in 10 C.F.R. §§ 63.111(a) and 63.111(b). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 5.8.2.2.1 at 5.8-5 states that the Bureau of Land Management granted a patented mining claim to Cind-R-Lite (Patent 27-83-0002) for 203 acres of land, as depicted in SAR Figure 5.8-1, and associated rights of way for an access road (N-43366) and a transmission line (NEV 066289). SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that the land associated with the patented mining claim and the rights-of-way lies wholly within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary.

Patented mining claim 27-83-0002 for 182.5 acres was granted in perpetuity to Hollie O. Allen by the Bureau of Land Management on November 29, 1982. *See* "Patented Mining Claim 27-83-0002" (11/29/1982), LSN# DEN001584160, solo page. It is not clear why SAR Subsection 5.8.2.2.1 at 5.8-5 states, to the contrary, that the mining claim covers 203 acres and is owned by Cind-R-Lite. Right-of-way N-43366 to construct, operate and maintain an access road (amounting to 6.06 acres) to the patented mining claim was granted until at least December 6, 2016 to Hollie O. Allen by the Bureau of Land Management on October 7, 1986. *See* "Right-of-Way Grant N-43366" (10/07/1986), LSN# DN2002064883 at 2. Right-of-way NEV 066289 for a transmission power line was granted in perpetuity to Valley Electric Association, Inc. by the Bureau of Land Management on August 23, 1966. *See* "Land Records for the Proposed Land Withdrawal Area of the Yucca Mountain Repository" (09/30/2007), LSN# DEN001574941 at 58 and 67. Since the patented mining claim and the two rights-of-way allow for access to and use of land located within DOE's land withdrawal area boundary and the pre-closure controlled area, DOE cannot exercise any jurisdiction and control over that land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b). Moreover, since the patented mining claim and the transmission power line right-of-way exist in perpetuity, DOE can never obtain a possessory interest in or seek a withdrawal of that land to satisfy 10 C.F.R. § 63.121(b). In addition, in light of the fact that DOE cannot exercise any jurisdiction or control over the land associated with the patented mining claim and rights-of-way, DOE cannot comply with radiation exposure and radioactive material release performance objectives set forth in 10 C.F.R. §§ 63.111(a) and

63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 5.8.2.2.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and references patented mining claim 27-83-0002 and rights-of-way N-43366 and NEV 066289, and its statement that the claim and two rights-of-way do not present an adverse human action that reduces the ability of the repository to isolate waste. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.2.2.1 is both inaccurate and materially incomplete because it fails to recognize that the claim and two rights-of-way lie wholly within DOE's land withdrawal area boundary and the pre-closure controlled area boundary. Therefore, DOE cannot exercise any jurisdiction and control over that land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b) or ensure the radiation exposure and radioactive material release values meet the performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-190 - UNPATENTED LODE AND PLACER MINING CLAIMS

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.2.2.2, which concludes that unpatented lode and placer mining claims on land administered by the Bureau of Land Management would have no adverse impact on repository operations, does not properly account for the fact that DOE does not exercise sufficient jurisdiction or control over the land on which the claims are located even though that land lies wholly within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries.

2. A brief summary of the basis for the contention

Unpatented lode and placer mining claims provide a member of the public with the right to occupy the land within the boundaries of the claim while searching for valuable minerals, and there are at least 60 active claims located on land that lies wholly within the land withdrawal area and the pre-closure area boundary for the Yucca Mountain repository.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(b), and 63.121(c), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and

adjacent areas. 10 C.F.R. § 63.121(b) (part of Subpart E) requires DOE to exercise jurisdiction and control over surface and subsurface estates outside the geologic repository operations area, which can include obtaining possessory interests in such estates or withdrawing such estates from patent under general mining laws, as necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. 10 C.F.R. § 63.121(c) requires DOE to exercise jurisdiction and control over activities outside the geologic repository operations area, which can include excluding members of the public, to ensure compliance with radiation exposure and radioactive material release performance objectives identified in 10 C.F.R. §§ 63.111(a) and 63.111(b). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 5.8.2.2.2 at 5.8-5 states that unpatented lode and placer mining claims, which provide a member of the public with the right to occupy the land within the boundaries of the claim while searching for valuable minerals, are primarily located in the far southwestern and south-central part of the area of land administered by the Bureau of Land Management as depicted on SAR Figure 5.8-1. SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 illustrate that the land associated with the unpatented mining claim lies wholly within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary.

DOE's Land Records for the Proposed Land Withdrawal Area of the Yucca Mountain Repository identify at least 60 active unpatented mining claims. *See* "Land Records for the Proposed Land Withdrawal Area of the Yucca Mountain Repository" (09/30/2007), LSN# DEN001574941 at 43, 49-50, 57 and 63. Since any one or all of the 60 active unpatented mining claims allow for access to and use of land located within DOE's land withdrawal area boundary and the pre-closure controlled area, DOE cannot exercise sufficient jurisdiction and control over that land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b). In addition, in light of the fact that DOE cannot exercise sufficient jurisdiction or control over the land associated with the unpatented mining claims, DOE cannot comply with radiation exposure and radioactive material release performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.2.2.2, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and DEN001574941, and its statement that the unpatented mining claims granted by the Bureau of Land Management would have no adverse impact on repository operations. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.2.2.2 is both inaccurate and materially incomplete because it fails to recognize that at least 60 active unpatented mining claims lie wholly within DOE's land withdrawal area boundary and pre-closure controlled area boundary. Therefore, DOE cannot exercise sufficient jurisdiction and control over that land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b) or ensure the radiation exposure and radioactive material release values meet the performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-191 - NYE COUNTY MONITORING WELLS

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.2.2.3, which states that right-of-way N-62848 granted to Nye County, Nevada to drill several monitoring wells has no adverse effect on the ability of the repository to meet performance objectives, does not account for the fact that DOE does not exercise sufficient jurisdiction or control over the land on which most of the wells are located even though that land lies wholly within the Yucca Mountain land withdrawal area and the pre-closure controlled area boundaries.

2. A brief summary of the basis for the contention

The Bureau of Land Management granted right-of-way N-62848 to Nye County, Nevada on February 25, 2000, which provides Nye County with the right for 25 years to construct, operate, and maintain 8 monitoring well sites for approximately 13 wells and two roads collectively amounting to approximately 12.49 acres of land located mostly within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries, and therefore, DOE does not exercise sufficient jurisdiction or control over the land on which most of the wells are located.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(b), and 63.121(c), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(b) (part of Subpart E) requires DOE to exercise jurisdiction and control over surface and subsurface estates outside the geologic repository operations area, which can include obtaining possessory interests in such estates or withdrawing such estates from patent under general mining laws, as necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. 10 C.F.R. § 63.121(c) requires DOE to exercise jurisdiction and control over activities outside the geologic repository operations area, which can include excluding members of the public, to ensure compliance with radiation exposure and radioactive material release performance objectives identified in 10 C.F.R. §§ 63.111(a) and 63.111(b). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.8.2.2.3 at 5.8-6 states that Nye County, Nevada has drilled several monitoring wells pursuant to right-of-way N-62848 that lie within the area shown on SAR Figures 5.8-1 and 5.8-3, and concludes that these wells have no adverse effect on the ability of the repository to meet performance objectives. SAR Figure 5.8-3 at 5.8-17 illustrates that Nye County has drilled 20 monitoring wells to the south of the geologic repository operations area.

SAR Figure 5.8-1 at 5.8-15 illustrates that the land on which most of those wells exist lie wholly within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries.

Right-of-way N-62848 states that Nye County, Nevada not only has the right to construct the wells, but also the right to operate and maintain the wells until at least February 25, 2025. *See* "N-62848 Right-of-Way Grant Amendment" (02/05/2005), LSN# DN2002142687 at 1. DOE's land records reveal that 17 of the monitoring wells lie wholly within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary. "Land Records for the Proposed Land Withdrawal Area of the Yucca Mountain Repository" (09/30/2007), LSN# DEN001574941 at 13. Since right-of-way N-62848 allows for access to and use of land associated with those 17 wells and that land is located within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries, DOE cannot exercise sufficient jurisdiction and control over that land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b). In addition, in light of the fact that DOE cannot exercise sufficient jurisdiction or control over the land associated with 17 of the monitoring wells, DOE cannot comply with radiation exposure and radioactive material release performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 5.8.2.2.3, which in turn relies on SAR Figures 5.8-1 and 5.8-3, right of way N-62848 and reference DEN001574941, and its statement that the right-of-way granted to Nye County, Nevada for monitoring wells has no adverse effect on the ability of the repository to meet performance objectives. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.2.2.3 is both inaccurate and materially incomplete because it fails to recognize that 17 of the monitoring wells lie on land wholly within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries. Therefore, DOE cannot exercise sufficient jurisdiction and control over that land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b) or ensure the radiation exposure and radioactive material release values meet the performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-192 - LAND OUTSIDE DOE'S RIGHTS-OF-WAY

1. A statement of the contention itself

Legal issue: SAR Subsection 5.8.1.1, which identifies 5 areas of land in which DOE claims some type of legal interest (i.e., right-of-ways N-48602 and N-47748, Public Land Orders 7653 and 6802/7534 and the Memorandum of Agreement governing the ranch boundary), fails to address whether DOE has any type of legal interest in 3 other areas of land lying outside those 5 areas but within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries and thus does not properly account for the fact that for those 3 additional areas DOE does not exercise any jurisdiction and control.

2. A brief summary of the basis for the contention

Within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries DOE identifies 5 areas of land for which it holds some legal interest – right-of-way N-48602, right-of way N-47748, Public Land Order 7653, Public Land Orders 6802/7534, and the Memorandum of Agreement governing the ranch boundary – however, there are areas of land north of right-of-way N-48602, southwest of right-of-way N-47748, and north, northeast, and southeast of the ranch boundary that lie within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries for which DOE does not identify any legal interest, and therefore DOE cannot exercise the requisite jurisdiction and control.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(b), and 63.121(c), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that no construction authorization may be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(b) (part of Subpart E) requires DOE to exercise jurisdiction and control over surface and subsurface estates outside the geologic repository operations area as necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. 10 C.F.R. § 63.121(c) requires DOE to exercise jurisdiction and control over activities outside the geologic repository operations area to ensure compliance with radiation exposure and radioactive material release performance objectives identified in 10 C.F.R. §§ 63.111(a) and 63.111(b). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SAR Subsection 5.8.1.1 at 5.8-3 identifies 5 areas of land for which DOE holds some legal interest – right-of-way N-48602, right-of way N-47748, Public Land Order 7653, Public Land Orders 6802/7534, and the Memorandum of Agreement governing the ranch boundary – and refers to SAR Figure 5.8-1 for depiction of those areas. SAR Figure 5.8-1 at 5.8-15 reveals three areas of land within the Yucca Mountain land withdrawal area boundary for which DOE does not hold any legal interest: (a) land north of right-of-way N-48602, (b) land southwest of right-of-way N-47748, and (c) land north, northeast, and southeast of the ranch boundary. SAR

Figure 5.8-2 at 5.8-16 reveals that the Yucca Mountain land withdrawal boundary is co-extensive with the pre-closure controlled area boundary.

Since there exist three areas of land within the Yucca Mountain land withdrawal area and pre-closure controlled area for which DOE exercises no jurisdiction or control, DOE cannot prevent adverse human actions on that land that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b). In addition, for those three areas of land DOE cannot ensure the radiation exposure and radioactive material release performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) are satisfied as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2, and its statements regarding 5 types of legal interests in land held by DOE within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.1.1 is materially incomplete because it fails to identify any legal interest held by DOE to 3 land areas lying outside the 5 identified areas but within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries. Therefore, DOE cannot exercise the jurisdiction and control over those 3 additional areas of land so as to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation as required by 10 C.F.R. § 63.121(b) or ensure the radiation exposure and radioactive material release values meet the performance objectives set forth in 10 C.F.R. §§ 63.111(a) and 63.111(b) as required by 10 C.F.R. § 63.121(c). As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-193 - LAND WITHDRAWAL

1. A statement of the contention itself

SAR Subsection 5.8.1.1, which identifies DOE's legal interest in land for the geologic repository operations area and the surrounding land within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary, admits that DOE's interests do not authorize the construction and operation of the repository and therefore Yucca Mountain cannot be licensed by the NRC.

2. A brief summary of the basis for the contention

DOE admits in SAR Subsection 5.8.1.1 that it does not currently have the requisite legal interest in land required to construct and operate a geologic repository at Yucca Mountain, and although DOE has requested legislative action to withdraw the land within the Yucca Mountain land withdrawal area and pre-closure controlled area boundaries, such legislation has not been enacted, and therefore, NRC cannot license DOE to construct or operate the Yucca Mountain repository.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(a), 63.121(b), and 63.121(c), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the

controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(a) (part of Subpart E) requires the geologic repository operations area to be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use, and that all such lands must be held free and clear of all significant encumbrances. 10 C.F.R. § 63.121(b) requires DOE to exercise jurisdiction and control over surface and subsurface estates outside the geologic repository operations area as necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. 10 C.F.R. § 63.121(c) requires DOE to exercise jurisdiction and control over activities outside the geologic repository operations area to ensure compliance with radiation exposure and radioactive material release performance objectives identified in 10 C.F.R. §§ 63.111(a) and 63.111(b). This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 5.8.1.1 at 5.8-3 identifies DOE's legal interests in land for the geologic repository operations area and the surrounding land within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary, as depicted in SAR Figures 5.8-1 and 5.8-2, and admits that such interests do not authorize the construction and operation of the repository. SAR Subsection 5.8.1.1 at 5.8-2 states that DOE submitted to Congress a bill that would permanently withdraw the lands required to construct and operate a geologic repository at Yucca Mountain. SAR Figure 5.8-1 at 5.8-15 and Figure 5.8-2 at 5.8-16 depict the lands required for the geologic repository operations area as well as the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary.

By letter dated March 6, 2007, DOE submitted a bill to Congress that would permanently withdraw approximately 147,000 acres of land in Nye County, Nevada necessary for DOE to construct and operate a geologic repository at Yucca Mountain. *See* "Transmittal of Legislative Proposal Entitled 'Nuclear Fuel Management and Disposal Act'" (03/06/2007), LSN# DEN001586407 at 5-11. As of the date of the filing of this contention, the bill has not been enacted by Congress nor signed by the President. Since DOE admits that it does not have the requisite legal interests in land for the geologic repository operations area and the surrounding Yucca Mountain land withdrawal area boundary and pre-closure controlled area boundary, DOE cannot comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a), 63.121(b) and 63.121(c). Therefore, Yucca Mountain cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges SAR Subsection 5.8.1.1, which in turn relies on SAR Figures 5.8-1 and 5.8-2 and reference DEN001586407, which admits that DOE does not possess the requisite legal interest in land for the geologic repository operations area and the surrounding Yucca Mountain land withdrawal area and pre-closure controlled area boundaries and that a legislative enactment is required to permanently withdraw that land for the construction and operation of the Yucca Mountain repository. DOE's admission demonstrates that the License Application does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(a), 63.121(b) and 63.121(c). Therefore, Yucca Mountain cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

NEV-SAFETY-194 - VH-1 WATER RIGHTS

1. <u>A statement of the contention itself</u>

Legal issue: SAR Subsection 5.8.4, which states that well VH-1 provides DOE with a permanent right to 2.3 acre-feet of water annually, fails to properly account for the fact that the water right is not sufficient to accomplish the purpose of the geologic repository operations area.

2. <u>A brief summary of the basis for the contention</u>

EIS Subsection 4.1.3.3 and Table 4-11 identify the maximum water demand during the construction and operation of the Yucca Mountain repository as approximately 290 acre-feet per year; however, DOE's only currently available water appropriation permit from the State of Nevada permits the withdrawal of 2.3 acre-feet per year and that water cannot be used for the construction or operation of the Yucca Mountain repository.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 63.21(c)(24), 63.31(a)(3), 63.121(b) and 63.121(d), which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. § 63.31(a)(3) provides that a construction authorization will not be issued unless the LA satisfies the requirements of 10 C.F.R. § 63.21 and the site and design comply with 10 C.F.R. Part 63, Subpart E. 10 C.F.R. § 63.21(c)(24) requires a description of the controls that DOE will apply to restrict access and to regulate land use at the Yucca Mountain site and adjacent areas. 10 C.F.R. § 63.121(d) (part of Subpart E) requires DOE to obtain water rights as may be needed to accomplish the purpose of the geologic repository operations area,

and to include those water rights in the additional controls to be established under paragraph (b). 10 C.F.R. § 63.121(b) requires DOE to establish appropriate controls outside the geologic repository operations area including jurisdiction and control over subsurface estates. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsection 5.8.4 at 5.8-8 states that DOE received water appropriation permits for four wells from the State of Nevada, and that all the permits except the permit for the VH-1 well expired on April 2, 2002. SAR Subsection 5.8.4 at 5.8-8 further states that well VH-1 only provides DOE with a permanent right to 2.3 acre-feet of water annually, and DOE admits that this supply will not provide for the projected water demands to construct and operate the Yucca Mountain repository. SAR Figure 5.8-1 at 5.8-15 depicts the location of well VH-1, which lies southwest of the geologic repository operations area and within the Yucca Mountain land withdrawal area boundary and the pre-closure controlled area boundary. FEIS Subsection 4.1.3.3 at 4-27 through 4-28 and FEIS Table 4-11 at 4-27 predict DOE's water needs during the construction of the Yucca Mountain repository to be between 160 and 210 acre-feet per year and during operations to be between 230 and 290 acre-feet per year.

When the State of Nevada issued Permit No. 57375 for well VH-1 to DOE on October 23, 1992, the State Engineer limited the use of the permit to road construction, dust suppression, tunneling, pad construction, scientific tests, culinary and other related site uses, and required DOE to provide proof of beneficial use (no later than April 9, 1994) of no greater than 61.38 acre-feet annually. *See* Letter from R.M. Turnipseed, State Engineer, State of Nevada to DOE (10/23/1992), LSN# DEN001373887 at 4 and 6. SAR Subsection 5.8.4 at 5.8-8 states that DOE filed proof of beneficial use to establish a permanent right to 2.3 acre-feet of water annually from well VH-1.

Since the water appropriated from well VH-1 is insufficient to support the projected demand for the construction or operation of the Yucca Mountain repository, and no amount of water from well VH-1 can be used for that purpose, the water rights under Permit No. 57375 are not sufficient to comply with the requirements of 10 C.F.R. §§ 63.21(c)(4), 63.121(b) and 63.121(d). Therefore, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Subsection 5.8.4, which in turn relies on SAR Figures 5.8-1, FEIS Subsection 4.1.3.3, FEIS Figure 4-11, and DOE reference DEN001373887, which states that the water right to 2.3 acre-feet annually from well VH-1 will not provide for the projected water demands to construct and operate the repository. As indicated above, there is sufficient information to believe that DOE's discussion in SAR Subsection 5.8.1.1 is materially incomplete because it fails to acknowledge that the water from well VH-1 cannot be used for the construction or operation of the Yucca Mountain repository. As a result, SAR Subsection 5.8.4 does not comply with the requirements of 10 C.F.R. §§ 63.21(c)(24), 63.121(b) and 63.121(d) because DOE lacks the appropriate controls including water rights outside the geologic operations area to accomplish the purpose of the geologic operations area. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(a)(3).

(c) Other Pre-Closure

NEV-SAFETY-195 - 9/11 TERRORIST ATTACK

1. A statement of the contention itself

DOE's security measures for physical protection of HLW, as described in section 3 of the General Information portion of the LA at 3-1 to 3-9, are inadequate to protect public health and safety because DOE fails to provide any evidence that there will be any protective or mitigation measures to respond adequately to a terrorist attack using aircraft, including an attack using large aircraft as occurred on 9-11.

2. A brief summary of the basis for the contention

At the very least, a physical security plan (including appropriate design measures) must be designed to respond to attacks that have occurred historically against important United States targets, and this includes a terrorist attack using large aircraft as occurred on 9-11. NRC's prior refusal to include such attacks in its design basis threat (DBT), because such threats are not within the reasonable capability of the private sector, do not apply to DOE in this proceeding.

3. A demonstration that the contention is within the scope of the hearing

This issue is within the scope of the finding required by 10 C.F.R. § 63.31(a)(1) and within the scope of the hearing as defined in section II, paragraph 1 of the Notice of Hearing. This same issue was raised in Nevada's June 4, 2008 petition to reject DOE's tendered application, and in response, the Commission ruled in CLI-08-20 that "[t]he matters raised in Nevada's . . . filings would be appropriately raised for consideration in response to [the] notice of hearing," and that dismissal of Nevada's petition was "without prejudice to the petitioners' right to pursue identical claims, but in the form of proposed adjudicatory contentions. . . ." CLI-08-20 at 4, 5. If, notwithstanding CLI-08-20, the Board finds that this issue constitutes a rule challenge within the meaning of 10 C.F.R. § 2.335, then Nevada respectfully requests a certification back to the Commission for a waiver or exception pursuant to 10 C.F.R. § 2.335(d) because, for the reasons given in "supporting facts or opinions" below, and in paragraphs 2 through 4 of the attached affidavit of Charles J. Fitzpatrick (Attachment 2), special circumstances with respect to the subject matter of this proceeding are such that the application of the existing rule (particularly 10 C.F.R. §§ 73.51(b)(2), 73.51(b)(3), and 73.51(d)) would not serve the purpose for which the rule was adopted.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

This contention challenges NRC's ability to make the finding required by 10 C.F.R. § 63.31(a)(1) without any evidence that there will be any protective or mitigation measures to respond adequately to a terrorist attack using aircraft, including an attack using large aircraft as occurred on 9-11. The contention is therefore material.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The Commission explained in a recent rulemaking defining a DBT that a DBT considers "the [terrorist] tactics that have been observed in use." 72 Fed. Reg. 12705, 12708 (03/19/2007) [2007 DBT Rule]. Given the tactics in use on 9-11, this approach to developing the DBT would require a physical security DBT to include airborne attacks, including airborne attacks using a large commercial airliner. However, the Commission explained further that "the DBTs are based on adversary characteristics which a private sector security force can reasonably be expected to defend." 2007 DBT Rule at 12713. Thus the 2007 definition of the DBT was influenced by the Commission's judgment with respect to the proper division of responsibility between the public and private sectors. This consideration played an especially critical role in the Commission's deliberations with respect to airborne attacks. The Commission omitted airborne attacks from its

DBT because "the airborne threat is one that is beyond what a private security force can reasonably be expected to defend against." 2007 DBT Rule at 12710.

However, this consideration does not apply to DOE, an Executive Branch Agency with an important national security component and numerous well-established relationships with the President and other agencies such as the Departments of Homeland Security and Defense. Moreover, this consideration does not apply to the selection of design measures to counter terrorist attacks, which are generally within an applicant's control, especially at the pre-construction stage. Therefore, the Commission's consistent approach of considering "the [terrorist] tactics that have been observed in use" requires, in the case of Yucca Mountain, a DBT that includes airborne attacks, including attacks like those that occurred on 9-11.

The above discussion sets forth special circumstances applicable to the Yucca Mountain application. The specific aspect of the proceeding at issue is the DBT, and use of the current DBT would not serve the purposes for which it was adopted because the purpose of recognizing the limits of the private sector in protecting against terrorism cannot be served in this proceeding, and thus applying a DBT that omits airborne attacks without sufficient reason would not protect the public health and safety. The above discussion constitutes a prima facie case as required by 10 C.F.R. § 2.335(b).

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges section 3 of the General Information portion of the LA, especially section 3.2 at 3-3 which describes the performance objectives and requirements of its physical protection plan as satisfying the requirements of 10 C.F.R. § 73.51(b)(1) and (2), and section 3.5 at 3-5 which describes its physical barrier system as meeting the requirements of 10 C.F.R. § 73.51(d). These regulations are inadequate to protect public health and safety, and therefore, DOE's descriptions are inadequate. The supporting reasons are given above in "Supporting facts or opinions" and may be summarized as follows. At the very least, a physical security plan (including appropriate design measures) must be designed to respond to attacks that have occurred historically against important United States targets, and this includes a terrorist attack using aircraft, including an attack using large aircraft as occurred on 9-11. NRC's prior refusal to in include such attacks in its DBT because such threats are not within the reasonable capability of the private sector do not apply to DOE in this proceeding.

NEV-SAFETY-196 - DESCRIPTION OF SECURITY MEASURES

1. A statement of the contention itself

The application does not describe the detailed security measures required for physical protection as required by the regulations.

2. A brief summary of the basis for the contention

Instead of describing the detailed security measures, the application merely declares that there will be a physical protection plan to be provided "no later than 180 days after the NRC issues a construction authorization" and that whatever DOE will later decide to do will be "compliant with applicable portions of 10 C.F.R. Part 73." GI Section 3. *See also id.* Sections 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.10, 3.11, 3.12.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with the express statutory and regulatory requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

Title 10 C.F.R. § 63.21(a) provides that, "[a]n application consists of general information and a Safety Analysis Report," and that DOE's "application must be as complete as possible in the light of the information that is reasonably available at the time of docketing." 10 C.F.R. § 63.21(b)(3) prescribes that the "general information" (GI) in the application "must include," among other things, "a description of the detailed security measures for physical protection of high-level radioactive waste in accordance with § 73.51 of this chapter," and that "[t]his plan must include the design for physical protection, the licensee's safeguards contingency plan, and security organization personnel training and qualification plan. The plan must list tests, inspections, audits, and other means to be used to demonstrate compliance with such requirements." *See also* NUREG-1804 § 1.3 (specifying that the "description must include the design for physical protection, the licensee's safeguard contingency plan, and security organization and personnel training and qualification plan"). 10 C.F.R. § 73.51 specifies requirements for the physical protection of stored spent nuclear fuel and high-level radioactive waste. This contention alleges non-compliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Contrary to 10 C.F.R. § 63.21(b)(3), the LA does not provide "a description of the detailed security measures for physical protection of high-level radioactive waste in accordance with [10 C.F.R.] § 73.51." Instead, GI Section 3 at 3-1 states that "[a] Physical Protection Plan, compliant with applicable portions of 10 CFR Part 73, will be submitted to the U.S. Nuclear Regulatory Commission (NRC) no later than 180 days after the NRC issues a construction authorization," and then succeeding sections track each acceptance criterion of NUREG-1804 § 1.3 and its Subparts, and announce that these criteria will be met by whatever will be provided.

Thus, for example, GI Section 3 at 3-1 states that "the Physical Protection Plan," to be submitted up to 180 days *after* construction authorization, "*will describe* the physical protection system for the geologic repository operations area (GROA), which will be designed to protect against a loss of control of the facilities that could cause radiation exposures exceeding the doses described in 10 CFR 72.106." (Emphasis added). GI Section 3 at 3-1 and 3-2 goes on to state (emphasis added) that "[t]he plan *will be developed and maintained to provide a description*," of the:

- Isolation zones, as defined in 10 C.F.R. § 73.2;

- GROA, including the nature and the amount of wastes, as well as a plan implementation schedule that meets the performance objectives of 10 C.F.R. § 73.51;
- Security organization, physical protection systems, and other means that are used to protect the GROA against a loss of control that could cause radiation exposures exceeding the doses described in 10 C.F.R. § 72.106;
- Physical barrier, access control, detection, surveillance, alarm, and communication subsystems that protect against unauthorized penetration and unauthorized removal, theft, or diversion of nuclear material and against radiological sabotage;
- Equipment test and maintenance activities that provide confidence in the effectiveness, availability, reliability, maintainability, and integrity of security equipment and subsystems; and
- Safeguards Contingency Plan for responding to unauthorized penetrations of or activities within the protected area, identifying predetermined responses to safeguards contingency events, and the process for reporting safeguards events to the NRC, consistent with the requirements of 10 C.F.R. Part 73, Appendix G.

GI Subsection 3.1 at 3-3 similarly states, among other things, that the "[t]he Physical Protection Plan *will describe* the GROA," "*will* specify the locations of physical protection systems, subsystems, and major components of the GROA facilities," "*will* identify tests, inspections, audits, and other means to be used to demonstrate compliance with 10 CFR 73.51," and "*will* include a schedule for implementation of physical protection") (emphasis added).

GI Subsection 3.2 at 3-3 states, among other things, that "[t]he Physical Protection Plan *will* meet the general performance objectives and requirements of 10 CFR 73.51(b)(1)," "*will* describe those portions of the physical protection system for which redundant and diverse subsystems and components are necessary in order to meet the requirements of 10 CFR 73.51(b)(2)," "*will* be designed and performance-tested to provide assurance that the system functions as intended," and "*will* describe the design and how the system is tested and maintained to ensure its continued effectiveness, availability, reliability, and maintainability." (Emphasis added).

GI Subsection 3.3 at 3-4 states, among other things, that "[t]he Physical Protection Plan *will address* protection of the protected area of the GROA against a loss of control that could cause radiation exposures exceeding the dose described in 10 CFR 72.106." (Emphasis added).

GI Subsection 3.4 at 3-4 states, among other things, that "[t]he Physical Protection Plan *will describe* how the security organization manages, controls, and implements the physical protection system while continually assessing and maintaining its effectiveness. The plan *will describe* the security organization that will be established and maintained. This security organization will operate in accordance with written procedures and written agreements, and the plan *will indicate* whether the security force is composed of federal employees or a contract security force." (Emphasis added). *See also, e.g.*, GI Subsection 3.5 at 3-5 ("The protected area of the GROA will be surrounded by physical barriers as defined in 10 CFR 73.2."); GI Subsection 3.6 at 3-6 ("The Physical Protection Plan will describe access control subsystems and address applicable requirements for personnel access authorization for the protected area."); and GI Subsection 3.8 at 3-7 ("The Physical Protection Plan will describe the communication subsystem, in accordance with the requirements of 10 CFR 73.51(d)(8)").

DOE's promise to provide a description of the security measures for its physical protection plan in the future does not meet the requirements of 10 C.F.R. §§ 63.21(b)(3) and 73.51, and also fails to provide information that is reasonable available to DOE. Thus, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.21(a).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

As explained above, GI Section 3 and Subsections 3.1 to 3.8 and 3.10 to 3.12, and similar subsections, purport unilaterally to defer until up to 180 days after the construction authorization DOE's obligation to comply with the requirement in 10 C.F.R. § 63.21(b)(3) to provide "a description of the detailed security measures for physical protection of high-level radioactive waste in accordance with [10 C.F.R.] § 73.51." Thus, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.21(a).

NEV-SAFETY-197 - PHYSICAL PROTECTION STANDARD

1. A statement of the contention itself

DOE purports to adopt security measures for physical protection in accordance with standards that date largely from 1998 but, because the Commission has recently determined that those standards are inadequate in light of the terrorist attacks of September 11, 2001, DOE's plans are not adequate to protect the public and safety or the common defense and security. This contention petitions for a rule challenge pursuant to 10 C.F.R. § 2.335.

2. A brief summary of the basis for the contention

DOE's license application purports to adopt security measures for physical protection that the Commission already declared "are not adequate to protect the common defense and security or the public health and safety." 72 Fed. Reg. 72,522, 72,524 (12/20/2007).

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether the standard that DOE purports to meet complies with the regulatory requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 63.31(a)(2) and (b) state that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is a reasonable expectation that the materials can be disposed of without unreasonable risk to the health and safety of the public, and that there is reasonable assurance that the activities proposed will not be inimical to the common defense and security. In reaching this determination, 10 C.F.R. § 63.31(a)(3)(i) requires the LA to satisfy the requirement contained in Section 63.21. 10 C.F.R. § 63.21(b)(3) requires a

description of the detailed security measures for physical protection of high-level radioactive waste in accordance with 10 C.F.R. § 73.51.

This contention seeks an exception to a rule the Commission has already declared is inadequate. 10 C.F.R. § 2.335(b) provides, in part, that "[a] party to an adjudicatory proceeding subject to this part may petition that the application of a specified Commission rule or regulation or any provision thereof, of the type described in paragraph (a) of this section, be waived or an exception made for the particular proceeding. The sole ground for petition of waiver or exception is that special circumstances with respect to the subject matter of the particular proceeding are such that the application of the rule or regulation (or a provision of it) would not serve the purposes for which the rule or regulation was adopted." In accordance with this provision, paragraphs 5 through 7 of the attached affidavit of Charles J. Fitzpatrick (Attachment 2) identify the specific aspect or aspects of the subject matter of the proceeding as to which the application of the rule or regulation (or provision of it) would not serve the purposes for which the rule or regulation was adopted. 10 C.F.R. § 2.335(b).

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The security measures for physical protection that DOE purports to apply are ones the Commission has already declared to be inadequate to protect the common defense, security, public health and safety. In 2007, the Commission wrote:

> The current regulations for ... security for a [geologic repository operations area ("GROA")] were developed under a different threat environment, and the threat environment has changed, as have the plans for surface operations at a GROA. The NRC now believes that a new regulatory approach for protecting a GROA is necessary. In addition, the DOE has not set forth a final concept of operations document for the GROA; therefore, the types and forms of material to be handled and disposed of at a GROA have not been finalized. The current security ... requirements for a GROA are not adequate to protect the common defense and security or the public health and safety.

72 Fed. Reg. 72,522, 72,524 (12/20/2007).

DOE’s security measures for physical protection purport to meet a standard that is "not adequate," therefore those measures and DOE’s compliance with them cannot be called adequate to protect the common defense, security, public health, and safety. The Commission must promulgate standards that are deemed to be adequate, and DOE must demonstrate compliance with such standards.

The State of Nevada previously filed an affidavit, pursuant to 10 C.F.R. § 2.335(b), that identifies the specific aspects of the subject matter of the proceeding as to which the application of the rule or regulation (or provision of it) would not serve the purposes for which the rule or regulation was adopted.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

GI Section 3 and Subsections 3.1 to 3.8 at 3-3 to 3-7 and 3.10 to 3.12 at 3-8 to 3-9, and similar subsections, state that DOE intends to conform its plan to existing regulations concerning security measures for physical protection. As these regulations are outdated and not adequate to protect the common defense and security or the public health and safety, DOE’s plan is similarly inadequate. As a result, the Commission cannot license Yucca Mountain pursuant to 10 C.F.R. § 63.31.

NEV-SAFETY-198 - MATERIAL CONTROL AND ACCOUNTING PLAN

1. A statement of the contention itself

DOE purports to adopt a material control and accounting program in accordance with standards that date largely from 1998 but, because the Commission has recently determined that those standards are inadequate in light of the terrorist attacks of September 11, 2001, DOE's plans are not adequate to protect the public and safety or the common defense and security. This contention petitions for a rule challenge pursuant to 10 C.F.R. § 2.335.

2. A brief summary of the basis for the contention

DOE's license application purports to apply material control and accounting regulations that the Commission has already declared "are not adequate to protect the common defense and security or the public health and safety." 72 Fed. Reg. 72,522, 72,524 (12/20/2007).

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether the standard that DOE purports to meet complies with the statutory requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 63.31(a)(2) and (b) state that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is a reasonable expectation that the materials can be disposed of without unreasonable risk to the health and safety of the public, and that there is reasonable assurance that the activities proposed will not be inimical to the common defense and security. In reaching this determination, 10 C.F.R. § 63.31(a)(3)(i) requires the LA to satisfy the requirement contained in Section 63.21. 10 C.F.R. § 63.21(b)(3) requires a description of the material control and accounting program that meets the requirements of

Section 63.78. 10 C.F.R. § 63.78 requires the material control and accounting program to be the same as that specified in 10 C.F.R. §§ 72.72, 72.74, 72.76 and 72.78.

This contention seeks an exception to a rule the Commission has already declared is inadequate. 10 C.F.R. § 2.335(b) provides, in part, that "[a] party to an adjudicatory proceeding subject to this part may petition that the application of a specified Commission rule or regulation or any provision thereof, of the type described in paragraph (a) of this section, be waived or an exception made for the particular proceeding. The sole ground for petition of waiver or exception is that special circumstances with respect to the subject matter of the particular proceeding are such that the application of the rule or regulation (or a provision of it) would not serve the purposes for which the rule or regulation was adopted." In accordance with this provision, paragraphs 8 through 10 of the attached affidavit of Charles J. Fitzpatrick (Attachment 2) identify the specific aspect or aspects of the subject matter of the proceeding as to which the application of the rule or regulation (or provision of it) would not serve the purposes for which the rule or regulation was adopted. 10 C.F.R. § 2.335(b).

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The material control and accounting program that DOE purports to apply is one the Commission has already declared to be inadequate to protect the common defense, security, public health and safety. In 2007, the Commission wrote:

> The current regulations for [material control and accounting ("MC&A")] ... for a [geologic repository operations area ("GROA")] were developed under a different threat environment, and the threat environment has changed, as have the plans for surface operations at a GROA. The NRC now believes that a new regulatory approach for protecting a GROA is necessary. In addition, the DOE has not set forth a final concept of operations document for the GROA; therefore, the types and forms of material to be handled and disposed of at a GROA have not been finalized. The current ... MC&A requirements for a GROA are not adequate to protect the common defense and security or the public health and safety.

72 Fed. Reg. 72,522, 72,524 (12/20/2007).

DOE's material control and accounting program purports to meet a standard that is "not adequate," therefore, that program and DOE's compliance with it cannot be called adequate to protect the common defense, security, public health and safety. The Commission must promulgate standards that are adequate and DOE must demonstrate compliance with those standards.

The State of Nevada previously filed an affidavit, pursuant to 10 C.F.R. § 2.335(b), that identified the specific aspects of the subject matter of the proceeding as to which the application of the rule or regulation (or provision of it) would not serve the purposes for which the rule or regulation was adopted.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

GI Sections 4 and Subsections 4.1.1 to 4.1.7 at 4-2 to 4-6, and 4.2 to 4.4 at 4-6 to 4-8, and similar subsections, state that DOE intends to conform its material control and accounting program to existing regulations. As these regulations are outdated and not adequate to protect the common defense and security or the public health and safety, DOE's plan is similarly inadequate. As a result, the Commission cannot license Yucca Mountain pursuant to 10 C.F.R. § 63.31.

NEV-SAFETY-199 - PERFORMANCE CONFIRMATION AND AVAILABLE TECHNOLOGY

1. A statement of the contention itself

SAR Chapter 4, which describes what purports to be DOE's Performance Confirmation Program, fails to provide sufficient description of key equipment and process activities critical to implementation of the Performance Confirmation Program as described, and some of the key activities needed for the Program, as described, rely impermissibly on technology development or integration that is not currently available.

2. A brief summary of the basis of the contention

The descriptions of the implementation methodology for SAR Subsections 4.2.1.2, 4.2.1.8, 4.2.1.11, 4.2.2.4, and 4.2.4.1 indicate that the specific technologies needed to meet data collection requirements were not available at the time of submittal of the license application, and therefore cannot be described even generally.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E

of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(17) requires a description of the performance confirmation program that meets the requirements of Subpart F. 10 C.F.R. Part 63.102(m) (part of Subpart E) requires a performance confirmation program to be conducted to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Key geotechnical and design parameters, including any interactions between natural and engineered systems and components, must be monitored throughout site characterization, construction, emplacement, and operation to identify any significant changes in the conditions assumed in the license application that may affect compliance with the performance objectives specified at Sections 63.113(b) and (c). 10 C.F.R. § 63.131(c) (part of Subpart F) requires the performance confirmation program to include in situ monitoring, laboratory and field testing, and in situ experiments as may be appropriate, Section 63.132(b) requires subsurface conditions to be monitored and evaluated against design assumptions, and Section 63.134(a) requires the condition of the waste package to be monitored. 10 C.F.R. Part 63.305(b) prohibits DOE from projecting increases or decreases of human knowledge or technology and requires DOE to assume that all factors remain constant as they are at the time of submission of the license application. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

SAR Subsections 4.2.1.2 at 4-16 (Seepage Monitoring), 4.2.1.8 at 4-24 (Drift Inspection), 4.2.1.11 at 4-28 (Thermally Accelerated Drift In-Drift Environment Monitoring), 4.2.2.4 at 4-32 (Thermally Accelerated Drift Thermal-Mechanical Monitoring), and 4.2.4.1 at 4-36 (Waste Package Monitoring) represent indispensable aspects of DOE's Performance Confirmation

Program because of the importance of their targets to the TSPA. Each of these topics is integral to and of high importance in any compliance determination based on the TSPA. The topics of these performance confirmation activities are among the most sensitive in the TSPA: seepage into drifts, drift degradation (both for drip shield emplacement and post-closure), in-drift environment, and waste package condition.

In each case, the objectives of the performance confirmation activity are discussed at a conceptual level, which is generally acknowledged to be preliminary and dependent on the future development of performance confirmation test plans for which no completion date is specified. For example, SAR Subsections 4.2.1.2 at 4-18, 4.2.1.8 at 4-25, and 4.2.2.4 at 4-33 state as follows, or in equivalent language that "high-temperature and high-radiation environments representative of post-emplacement conditions . . . require development of specific applications of the technology." Similarly, SAR Subsections 4.2.1.11 at 4-29 and 4.2.4.1 at 4-37 "require integration of specific technology applications to accomplish measurements and inspections" because of the high-temperature and high-radiation environments representative of post-emplacement conditions. In each case it is pointed out or implied that technology exists to carry out such monitoring and testing under benign conditions. However, in these untried cases the monitoring and testing must be carried out remotely under conditions of ambient high temperature and high radiation, while meeting the conventional standards and requirements for reliability, quality, precision, and accuracy. If the technology existed to overcome and perform adequately under these challenging conditions, the SAR would have so stated and demonstrated, at least by reference, which it has not.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

The SAR Subsections cited above demonstrate that DOE improperly is assuming the near-future availability of technology to meet the requirements for its performance confirmation program, without which the required performance confirmation would be ineffectual in meeting the requirements of 10 C.F.R. §§ 63.21(c)(17), 63.102(m), 63,131(c), 63.132(b), 63.134(a) and 63.305(b). DOE has provided no technical basis for its assumption, nor has it considered alternative methodologies in the event of not being able to provide required in situ monitoring and testing of some of the most important elements of repository performance.

NEV-SAFETY-200 - PERFORMANCE CONFIRMATION PROGRAM LEVEL OF INFORMATION

1. A statement of the contention itself

SAR Chapter 4, which describes what purports to be DOE's Performance Confirmation Program, fails to provide an adequate description of such a program because DOE's efforts to develop its Program are so incomplete that meaningful and reviewable descriptions are impossible.

2. A brief summary of the basis of the contention

SAR Subsection 4.2 describes the Performance Confirmation Program in terms of general conceptualizations and notes that planning is ongoing with methods and approaches subject to change, which demonstrates that the Performance Confirmation Program is simply a plan for a plan without substance or even an adequate description.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with the NRC requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(a)(2) states that the NRC may authorize construction of the GROA at the Yucca Mountain site if it determines that there is reasonable expectation the materials described in the application can be disposed of without unreasonable risk to the health and safety of the public. In reaching this determination, 10 C.F.R. § 63.31(a)(3) requires the LA to satisfy the requirements contained in 10 C.F.R. § 63.21, and the site and design comply with Subpart E of 10 C.F.R. Part 63. 10 C.F.R. § 63.21(c)(17) requires a description of the performance

confirmation program that meets the requirements of Subpart F. 10 C.F.R. § 63.2 defines performance confirmation as a program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives in Subpart E of Part 63. 10 C.F.R. Part 63.102(m) (part of Subpart E) requires a performance confirmation program to be conducted to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Key geotechnical and design parameters, including any interactions between natural and engineered systems and components, must be monitored throughout site characterization, construction, emplacement, and operation to identify any significant changes in the conditions assumed in the license application that may affect compliance with the performance objectives specified at Sections 63.113(b) and (c). 10 C.F.R. § 63.131(c) (part of Subpart F) requires the performance confirmation program to include in situ monitoring, laboratory and field testing, and in situ experiments as may be appropriate, Section 63.132(b) requires subsurface conditions to be monitored and evaluated against design assumptions, and Section 63.134(a) requires the condition of the waste package to be monitored. 10 C.F.R. Part 63.305(b) prohibits DOE from projecting increases or decreases of human knowledge or technology and requires DOE to assume that all factors remain constant as they are at the time of submission of the license application. This contention alleges noncompliance with these regulatory provisions and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The Performance Confirmation (PC) Plan (Nov. 2004), LSN# DEN001584610, is the primary basis for SAR Chapter 4. The following statement from the Plan's Addendum

(02/25/2008), LSN# DEN001590480, Section 3.5.1[a] at 1[a], provides some insight into DOE's view of the implementation of the requirement for a performance confirmation program:

> Parameters and methods considered in the PC Plan are sometimes conceptual in nature, as is common when considering future work. As the PC test plans are developed, the rigor necessary for planning the details of the activity and developing the expected limits may result in the need to make some changes to the activity as described in the PC Plan . . . . This distinction between the PC Plan and the PC test plans is necessary to ensure flexibility when testing and monitoring details are finalized in the PC Plans . . . . The performance confirmation program periodically updates the PC Plan to ensure that the information therein is consistent with the license baseline information and reflects the most current understanding of the postclosure safety analysis.

Of the twenty performance confirmation activities, only three have a referenced performance confirmation test plan or technical work plan: construction effects monitoring (SAR Subsection 4.2.2.3 at 4-31); seismicity monitoring (SAR Subsection 4.2.2.2 at 4-30); and precipitation monitoring (SAR Subsection 4.2.1.1 at 4-15). The remainder of the activities described in SAR Subsection 4.2 are without performance confirmation test plans or technical work plans, and thus are subject to all the caveats provided by DOE's above distinction between the Performance Confirmation Plan and performance confirmation test plans.

SAR Subsection 4.2 at 4-12, in describing the activities of the Performance Confirmation Program, states that "operational period activities are general conceptualizations," and that "[p]lanning for currently identified candidate performance confirmation activities is ongoing; methods and approaches other than those discussed here may be employed . . . ." These statements are indicative that, at least in respect to operational period activities, the Performance Confirmation Program is simply a plan for a plan for which there is no committed substance. SAR Subsection 4.2 at 4-12 acknowledges that the performance confirmation plans for activities during the repository operational period are "general conceptualizations" and that ongoing planning, including the identification of monitoring and testing parameters and development of testing methodologies, some of which do not exist in current technology, will be included in performance confirmation test plans, technical work plans, and test procedures that have yet to be formulated. However, SAR Subsection 4.2 provides no indication of when these plans and procedures are expected to be completed for regulatory review as part of the license application, despite the fact that they already should have been completed and described in the SAR as required.

DOE has failed to provide an adequate description of its Performance Confirmation Program, and SAR Subsection 4.2 fails to comply with the requirements of Part 63.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SAR Chapter 4 compliance with the requirements of 10 C.F.R. § 63.21(c)(17) to provide a description of the performance confirmation program, as defined in 10 C.F.R. § 63.2, and failure to implement the concept of Performance Confirmation, as described in 10 C.F.R. §§ 63.102(m), 63.131(c), 63.132(b), 63.134(a), and 63.305(b).

NEV-SAFETY-201 - RELIANCE ON PRELIMINARY OR CONCEPTUAL DESIGN INFORMATION

1. A statement of the contention itself

Legal Issue: The LA cannot be granted because it relies on preliminary or conceptual design information for both pre-closure and post-closure aspects.

2. A brief summary of the basis for the contention

10 C.F.R. Part 63, especially Sections 63.21, 63.24, 63.31, 63.101, 63.102, and 63.111 through 115, considered with its history and contemporaneous NRC and DOE interpretations, require an essentially one-step licensing process in which the final design must be submitted and approved before a construction authorization may be issued. Preliminary and conceptual design information of the type found in the LA is not final design information.

3. A demonstration that the contention is within the scope of the hearing

This issue challenges compliance with applicable NRC regulations which, under 10 C.F.R. § 63.31(a)(3), must be satisfied before a construction authorization may be issued. Further, it is within the scope of the hearing as provided in Section II, paragraph 1 of the notice of hearing. Further still, this same issue was raised in Nevada's June 4, 2008 petition to reject DOE's tendered application, and in response, the Commission ruled in CLI-08-20 that "[t]he matters raised in Nevada's . . . filings would be appropriately raised for consideration in response to [the] notice of hearing" and that dismissal of Nevada's petition was "without prejudice to the petitioners' right to pursue identical claims, but in the form of proposed adjudicatory contentions. . . ." CLI-08-20 at 4, 5.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

This issue challenges compliance with applicable NRC regulations which, under 10 C.F.R. § 63.31(a)(3), must be satisfied before a construction authorization may be issued. It therefore presents a material issue.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

This contention raises a purely legal question, and supporting facts and opinions are not necessary beyond those discussed below.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the legal sufficiency of DOE's description of its pre- and post-closure designs in all pages of SAR Subsections 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6, 1.2.7, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.5, 1.3.6, 1.4.1, 1.4.2, 1.4.3, 1.4.4, 1.5.2, 1.9, 2.1.2.2, and related sections. Specific examples of deficiencies are offered in Nevada's July 21, 2008 Supplement to its June 4, 2008 Petition Asking the NRC to Reject DOE's Yucca Mountain License Application as Unauthorized and Substantially Incomplete. In particular, there is no final TAD design. Also, DOE's own application planning documents call for the application to be based on preliminary design information. *See, e.g.*, LSN# DN2001625181 ("Desk Top Instructions for Preparing Preliminary Design Drawings for License Application"), Section 3.1, at 3 ("Engineering drawings prepared for LA will be preliminary design drawings").

Supporting reasons are that 10 C.F.R. Part 63, especially Sections 63.21, 63.24, 63.31, 63.101, 63.102, and 63.111 through 115, considered with its history and contemporaneous NRC and DOE interpretations, requires an essentially one-step licensing process where the final design must be submitted and approved before a construction authorization may be issued.

Preliminary and conceptual design information of the type found in the application is not final design information.

B. **NEPA Contentions**

(1) Transportation

NEV-NEPA-01 - TRANSPORTATION SABOTAGE SCENARIOS

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.3.4.2 and Appendix G.8, regarding transportation sabotage events, fail to evaluate reasonably foreseeable attack scenarios that could result in significantly greater consequences than the scenarios considered by DOE. This deficiency is significant because, without considering reasonably foreseeable attack scenarios, there is no adequate disclosure of environmental impacts under NEPA. If reasonably foreseeable attack scenarios were added, the disclosure of radiological impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

In the FSEIS, DOE evaluated four sabotage event scenarios, two each involving rail and truck casks loaded with commercial spent fuel, in which "a weapon or device (also referred to as a high-energy-density device)" was assumed to penetrate the cask and disperse its contents. (FSEIS Subsection 6.3.4.2, at 6-26 to 6-27; *see also* FSEIS Appendix G.8 at G-49). However, DOE has ignored a long history of analyses and comments involving reasonable multiple weapon events that vastly increase the potential radiation exposure to the public.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The FSEIS fails to consider reasonably foreseeable attack scenarios in which more than one weapon or device might be deployed against a spent fuel shipping cask. An attack involving more than one weapon or device could result in full perforation of a truck or rail cask, creating an exit hole in addition to the entry hole, significantly increasing the amount of materials released in both respirable and non-respirable form, and significantly increasing the consequences of the event. Use of a second weapon or device to further damage and disperse the contents of the cask could significantly increase the consequences of the event even if the cask was not fully perforated. The potential increased consequences of attack scenarios involving more than one weapon or device were described more than 25 years ago by the U.S. Army Ballistic Research Laboratory ("Department of the Army: Review of High Explosive Device Testing Against Spent Fuel Shipping Casks" (10/13/1983), LSN# NEV000005338 at 3-5). Similar concerns were raised in comments submitted to NRC in response to a proposed rulemaking in 1984 (R.J. Halstead, *et al.*, "State of Nevada Studies of Potential Terrorism and Sabotage Against Spent Fuel Shipments," Waste Management '01 Conference, February 25 – March 1, 2001, Tucson, AZ (03/01/2001), LSN# NEV000005298 at 5-6), in a contractor report prepared for the State of Nevada in 1998 ("Nuclear Waste Transportation Security and Safety Issues: The Risk of Terrorism and Sabotage Against Repository Shipments" (12/01/1998), LSN# NEV000001791 at 44-48), in Nevada's Petition for Rulemaking submitted to NRC in 1999 [accepted and docketed as PRM-73-10] ("The State of Nevada Petition to Institute Rulemaking Related to the Safeguards for Spent Nuclear Fuel Shipments Against Terrorism and Sabotage and to Initiate a Comprehensive Assessment of the Consequences of Radiological Sabotage, Docket No. PRM-73-10" (06/22/1999), LSN# DN2001412150 at 2), in comments and supporting analyses submitted to DOE on the Yucca Mountain Draft EIS in 2001 ("State of Nevada Comments on the U.S. Department of Energy's Supplement to the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250D-S"

(05/31/2001), LSN# NEV000000464 at 152-154) and on the Draft Repository SEIS in 2008 ("State of Nevada Comments on DOE's Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (DOE/EIS-0250F-S1D), 72 FR No. 197, October 12, 2007, 58071-58074" (01/09/2008), LSN# NEV000004957 at 12, 14).

Most recently, in an October 2008 report prepared for the State of Nevada, Radioactive Waste Management Associates (RWMA) evaluated the mechanisms and consequences of transportation sabotage events involving two weapons or devices similar to those evaluated by DOE in the SEIS. ("Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008), LSN# NEV000005444 at 5-7). The new RWMA report (NEV000005444 at 8-12, 19-25) concludes that a transportation sabotage event involving a two-weapon attack on a shipping cask in an urban area could result in population exposures of 2.6 to 6.3 million person-rems – that is, population exposures 50 to 200 times greater than estimated by DOE in the FSEIS. The two-weapon attack scenarios could also result in significantly higher doses to the maximum exposed individual (MEI), compared to the MEI doses estimated by DOE in the FSEIS. This deficiency is significant because, without considering reasonably foreseeable attack scenarios, there is no adequate disclosure of environmental impacts under NEPA. If reasonably foreseeable attack scenarios were added, the disclosure of radiological impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between Nevada and DOE regarding the evaluation of transportation sabotage events as discussed in the FSEIS Subsection 6.3.4.2 and Appendix G.8, specifically the definition of reasonably foreseeable attack scenarios and the consequences of such events. In the FSEIS Comment Response Document ("Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Summary, Volume I, II, and III" (06/01/2008), LSN# DEN001593669, Vol. III at CR-465), DOE asserts: "Further speculation about scenarios that could produce consequences 'worse' than those previously estimated would be unproductive and ineffective, breeding endless hypothesis and speculation, and crafting and analysis of scenarios would be based on pure conjecture and would not be supported by credible scientific evidence." Nevada contends that the FSEIS ignores more than 25 years of relevant technical literature which supports the evaluation of attack scenarios deploying more than one weapon or device. In addition to the evidence previously submitted to DOE in response to the 1999 Draft EIS (NEV000000464 at 52-154) and the 2007 Draft SEIS (NEV000004957 at 12, 14), Nevada has now developed additional documentation (NEV000005444, all) to support its contention that DOE has failed to meet its NEPA requirements regarding transportation sabotage events.

NEV-NEPA-02 - TRANSPORTATION SABOTAGE CLEANUP COSTS

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.3.4.2 and Appendix G.8 regarding transportation sabotage events, and FSEIS Appendix G.9.7 regarding cost of cleanup after accidents, fail to provide an estimate of the cost of cleanup and other economic impacts following a sabotage event that resulted in release of radioactive materials, even though DOE assumes that cleanup would occur. This deficiency is significant because, without considering the cleanup costs of reasonably foreseeable attack scenarios, there is no adequate disclosure of environmental impacts under NEPA. If the cleanup costs of reasonably foreseeable attack scenarios were added, the disclosure of radiological impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

In the FSEIS, DOE acknowledges the vulnerability of truck and rail shipping casks to various sabotage event scenarios, and estimates the potential public health impacts of attacks which release radioactive materials in urban and rural areas, but provides no estimate of the cost of cleanup after such events, and no estimate of other economic impacts. *See* FSEIS Subsection 6.3.4.2 at 6-26 through 6-31, and Appendix G.8 at G-48 through G-50. In FSEIS Appendix G.9.7 at G-55 through G-57, which discusses cost of cleanup after transportation accidents, DOE rejects the sabotage cleanup cost estimates developed by the State of Nevada as "unrealistically high" (*id*. at G-57) but provides no sabotage cleanup cost estimates of its own. Yet, the FSEIS states that after a sabotage incident resulting in a release, "DOE anticipates that . . . cleanup actions would be initiated." Subsection 6.3.4.2 at 6-24.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-

compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The FSEIS fails to estimate costs of cleanup following any of the transportation sabotage events evaluated by DOE, despite the DOE assumption that cleanup would occur, and despite the availability of computer models developed for DOE that can provide estimates of cleanup costs for such events. Using the RISKIND and RADTRAN models, the State of Nevada developed estimates of the cost of cleanup after the sabotage events postulated by DOE, and for more severe sabotage events, and provided these estimates in comments and supporting analyses submitted to DOE on the Yucca Mountain Draft EIS in 2001 ("State of Nevada Comments on the U.S. Department of Energy's Supplement to the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250D-S" (05/31/2001), LSN# NEV000000464 at 152-154) and on the Draft Repository SEIS in 2008 ("State of Nevada Comments on DOE's Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (DOE/EIS-0250F-S1D), 72 FR No. 197, October 12, 2007, 58071-58074" (01/09/2008), LSN# NEV000004957 at 12-14). Most recently, in an October 2008 report prepared for the State of Nevada ("Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008), LSN# NEV000005444, all), Radioactive Waste Management Associates (RWMA) re-evaluated earlier cleanup cost estimates and prepared new estimates for a range of sabotage event scenarios. According to Resnikoff and Travers (NEV000005444 at 11-19), cleanup costs following sabotage events similar to those evaluated by DOE in the FSEIS, in which the casks are penetrated but not perforated, could range from $3.5 billion to $45.8 billion (2008$). Transportation sabotage events in which the casks are fully perforated could result in cleanup costs of $463 billion to $648 billion (2008$). This deficiency is significant because, without considering the cleanup costs of reasonably foreseeable attack scenarios, there is no adequate disclosure of environmental impacts under NEPA. If the cleanup costs of reasonably foreseeable attack scenarios were added, the disclosure of radiological and economic impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between Nevada and DOE regarding the cost of cleanup following the transportation sabotage events evaluated in the FSEIS Subsection 6.3.4 and Appendix G.8. DOE has failed to provide any sabotage cleanup cost estimates of its own in the FSEIS, but has rejected the cost estimates Nevada submitted to DOE during NEPA reviews as unrealistically high. Nevada has prepared new and updated cost estimates ranging from $3.5 billion (2008$) to $45.8 billion (2008$) for sabotage events similar to those evaluated in the FSEIS, and cleanup costs of $463 billion to $648 billion (2008$) for more severe sabotage events. NEV000005444 at 11-19.

NEV-NEPA-03 - TRANSPORTATION ACCIDENT CLEANUP COSTS

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Appendix G.9.7, regarding the cost of cleanup from transportation accidents, fails to provide verifiable estimates of the costs of cleanup following severe transportation accidents that resulted in release of radioactive materials. This deficiency is significant because, without considering reasonably foreseeable transportation accidents and their effects including cleanup costs, there is no adequate disclosure of environmental impacts under NEPA. If reasonably foreseeable transportation accidents and their effects including cleanup costs were properly considered, the disclosure of radiological impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

In FSEIS Appendix G.9.7 at G-55 through G-57, DOE provides an estimate of the cost of cleanup after severe transportation accidents based on "prior studies" rather than analyses of the specific events identified in the FSEIS as "maximum reasonably foreseeable accidents," and suggests an upper bound estimate of accident cleanup costs based on an unrelated accident study prepared for the Cassini space mission. DOE rejects the accident cleanup cost estimates developed by the State of Nevada using computer models developed for DOE as "unrealistically high," but provides no evidence that DOE evaluated cleanup costs using the DOE-sponsored models. *Id.* The FSEIS must provide a verifiable estimate of cleanup costs because DOE assumes that after an accident resulting in a release ". . . cleanup actions would be initiated." FSEIS Subsection 6.3.4.2 at 6-24.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-

compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The FSEIS fails to provide verifiable estimates of the costs of cleanup following the transportation accidents evaluated by DOE, despite the DOE assumption that cleanup would occur, and despite the availability of computer models developed for DOE that can provide estimates of cleanup costs for such events. Based on prior studies, "DOE believes that the cost of cleaning up following such an accident could be a few million dollars" although "they could be less or 10 times greater, depending on the contributing factors." FSEIS Appendix G.9.7 at G-56. In the FSEIS Comment Response Document, Section 1.7.16 at CR-467, DOE states that the "costs for cleanup after a severe accident in which radioactive material was released could be in the range of $300,000 to $10 billion." However, DOE admits that the $10 billion figure "was not based on a truck or rail accident, but rather was based on a National Aeronautics and Space Administration study of potential reentry accidents for the Cassini space mission, which used a plutonium powered electricity generator." *Id*. at CR-467 through CR-468. DOE fails to explain why cost figures for a potential reentry accident involving the Cassini space mission are relevant to a truck or rail accident involving materials destined for the Yucca Mountain repository. Although DOE also notes that the current insured limit of responsibility for an accident that involved release of radioactive materials to the environment is $10.26 billion, *id* at CR-468, and FSEIS Appendix H.9.2 at H-20, DOE fails to explain why the level of insurance coverage has any bearing on the cost of cleanup.

Using the RISKIND and RADTRAN models, the State of Nevada developed estimates of the cost of cleanup after the severe accidents postulated by DOE, and for more severe transportation accidents, and provided these estimates in comments and supporting analyses submitted to DOE on the Yucca Mountain Draft EIS in 2001 ("State of Nevada Comments on the U.S. Department of Energy's Supplement to the Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250D-S" (05/31/2001), LSN# NEV000000464 at 146-152) and on the Draft Repository SEIS in 2008 ("State of Nevada Comments on DOE's Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (DOE/EIS-0250F-S1D), 72 FR No. 197, October 12, 2007, 58071-58074" (01/09/2008), LSN# NEV000004957 at 12-14). Nevada estimated that cleanup costs following a severe rail accident could be up to $189.7 billion. ("Worst Case Credible Nuclear Transportation Accidents: Analysis for Urban and Rural Nevada" (08/01/2001), LSN# NEV000002194 at 48). Most recently, in an October 2008 report prepared for the State of Nevada ("Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008), LSN# NEV000005444 at 13-14 and 16-18), Radioactive Waste Management Associates (RWMA) re-examined the assumptions used in RISKIND and RADTRAN and developed procedures for updating earlier cleanup cost estimates. This deficiency is significant because, without considering cleanup costs of reasonably foreseeable accidents, there is no adequate disclosure of environmental impacts under NEPA. If reasonably foreseeable transportation accidents and their effects including cleanup costs were properly considered, the disclosure of radiological impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between Nevada and DOE regarding the cost of cleanup following the transportation accidents evaluated in the FSEIS Appendix G.9.7. DOE has failed to provide verifiable cleanup cost estimates in the FSEIS, but has rejected as unrealistically high, the cost estimates Nevada developed using the RISKIND and RADTRAN models and submitted to DOE during NEPA reviews.

NEV-NEPA-04 - SHARED USE OPTION

1. A statement of the contention itself

Final Environmental Impact Statement for a Rail Alignment, DOE/EIS 0369 (06/2008) ("Rail Alignment FEIS" or "RA FEIS") Subsections 4.2.1 and 4.2.10, incorporated by reference in Section 6.4 of the Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") (*see* FSEIS at 6-1), fail to adequately evaluate operational impacts of the shared use option generally, and specifically fail to evaluate the potential operational impacts of induced traffic growth. This deficiency is significant because, without fully considering the operational impacts of shared use under common carrier obligations, there is no adequate disclosure under NEPA. If a reasonable discussion of the operational impacts of the shared use option was included, the disclosure of shared use operational impacts could be materially different. Therefore, the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

The Rail Alignment FEIS fails to fully evaluate operational impacts of the shared use option compared to a single-purpose rail line dedicated to repository transportation. Based on interviews with and surveys of existing businesses near the proposed alignment, DOE estimated that shared use would add about 8 one-way trains per week to the 17 one-way trains per week for shipments of spent nuclear fuel (SNF) and high-level radioactive waste (HLW), *see* RA FEIS at 2-116; however, DOE failed to evaluate any increase in the number of trains due to induced traffic growth.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-

compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The Rail Alignment FEIS fails to consider reasonably foreseeable increases in rail traffic under the shared use option beyond the estimates based on interviews with existing businesses. In comments filed with DOE on the draft version of the Rail Alignment EIS, the State of Nevada noted,

> The potential for unplanned expansion of a shared use railroad, for uses such as multiple daily round-trip deliveries of coal in mile-long dedicated trains, is part of what transportation planners refer to as "induced traffic." Research into travel behavior has consistently shown that expanding infrastructure capacity leads to additional travel demand. The degree to which this "induced traffic" occurs varies according to the congestion on the corridor; however, it is clear that the problem of induced traffic is real. The Draft Rail Alignment EIS does not address the problem of increasing traffic and increased impacts due to shared use of the Caliente rail line.

(State of Nevada Comments on DOE's Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada – Nevada Rail Transportation Corridor – DOE/EIS-0250F-S2DE and DOE's Draft Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada – DOE/EIS-0369D (01/09/2008), LSN# NEV000004904 at 14.)

Operation of the Caliente rail line as a common carrier could result in large-scale rail shipments to coal-fired power plants, bio-fuels or other energy production facilities, and/or solid waste recycling and disposal facilities. For example, major railroads are actively promoting use of Powder River Basin coal from Montana and Wyoming as fuel for new power plants. A single new 500 MW coal-fired power plant requires about 2 million tons of coal per year ("BNSF

Railway, Montana Energy Summit, October 18-19, 2005, Bozeman, MT, Presentation by Tom Kraemer, Group Vice President - Coal" (10/18/2005), LSN# NEV000005450, all). Assuming unit trains hauling about 120 cars per train, with 100 tons of coal per car, a single new 500 MW coal-fired power plant would require about 330 one-way trains per year (165 trains loaded, 165 trains empty).

Induced traffic could result in shipments, and resulting impacts, equal to or greater than repository shipments. DOE made no effort to evaluate induced traffic in the Rail Alignment FEIS. Instead, DOE merely asserts that, "While there would be some limited potential for induced growth impacts, the specific locations and scope of these actions is unknown at this time and any such actions should be small because DOE would construct the rail line through rural areas of Nevada with limited future prospects for development." RA FEIS, Comment Response Document at CRD3-37.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

There is a genuine dispute between the State of Nevada and DOE regarding the potential impacts of the shared use option, especially regarding potential induced traffic impacts. Nevada believes that induced traffic could result in shipments equal to or greater than repository shipments.

NEV-NEPA-05 - RADIOLOGICAL REGIONS OF INFLUENCE FOR TRANSPORTATION

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsections 3.2.2 and 6.4.1, and Final Environmental Impact Statement for a Rail Alignment, DOE/EIS 0369 (06/2008) ("Rail Alignment FEIS" or "RA FEIS") (incorporated by reference in the FSEIS at 6-1) Subsection 3.2.10, which address the radiological regions of influence for transportation, fail to apply the preferred method of analysis consistently for transportation impacts in Nevada and nationally. This failure is significant because without consistently evaluating the radiological regions of influence for transportation DOE has failed to adequately assess their environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS and the RA FEIS, neither document can be adopted by the NRC.

2. A brief summary of the basis for the contention

Both FSEIS Subsection 3.2.1 and RA FEIS, 3.1 adopt the same definitions for the regions of influence (ROIs) for radiological impacts of incident-free transportation (i.e., 0.8 kilometers or 0.5 miles on either side of the transportation route centerline) and for radiological impacts of transportation accidents and sabotage (i.e., 80 kilometers or 50 miles on either side of the transportation route centerline). However, the FSEIS and the RA FEIS fail to consistently apply the radiological ROIs used to assess transportation impacts within the Caliente and Mina rail alignments, in relation to transportation impacts in other parts of Nevada, and in relation to transportation impacts nationally.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-

compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

RA FEIS Subsection 3.2.10.1.2 and 3.3.10.1.2 provide detailed information regarding exposed populations and health and safety impacts within the radiological regions of influence (ROIs) along the Caliente and Mina alignments. However, neither the FSEIS nor the RA FEIS provide comparable information for the radiological ROIs along existing routes in other parts of Nevada and nationally. Specifically, DOE has failed to provide population and dose information for the ROIs along rail and highway routes in the Las Vegas metropolitan area. Analyses prepared for the State of Nevada, based on 2005 Bureau of Census estimates, concluded that about 95,000 residents currently live within one-half mile of the Union Pacific rail route in Las Vegas, and about 113,000 residents currently live within one-half mile of the highway routes in Las Vegas. There are also 34 hotels with 49,000 hotel rooms located within one-half mile of the rail route in Las Vegas. The State of Nevada estimates that more than 1.8 million residents live within the 50 mile region of influence for accidents and sabotage, along potential truck and rail routes, in southern Nevada and adjacent areas of Arizona, California and Utah. *See* "State of Nevada Perspective on the U.S. Department of Energy Yucca Mountain Transportation Program – 8154" (02/24-28/2008) (LSN# NEV000005266) at 16-18, and "Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008) (LSN# NEV000005444) at 2-4.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the reporting of information regarding exposed populations and the evaluation of health and safety impacts within the radiological regions of influence along the Caliente and Mina alignments, along existing routes in other parts of Nevada, and nationally. DOE has provided this information only for the ROIs along the Caliente and Mina alignments. Nevada believes that the same information must be provided for the ROIs along existing routes in other parts of Nevada, and nationally.

This deficiency is significant because, without full consideration of exposed populations and health and safety impacts within the transportation radiological regions of influence, there is no adequate evaluation of environmental impacts as required under NEPA. Because those environmental impacts could be materially different from that presented in the FSEIS and the RA FEIS, neither document can be adopted by the NRC.

NEV-NEPA-06 - CALIENTE RAIL ALIGNMENT PLAN AND PROFILE INFORMATION

1. A statement of the contention itself

Final Environmental Impact Statement for a Rail Alignment, DOE/EIS 0369 (06/2008) ("Rail Alignment FEIS" or "RA FEIS") Subsection 2.2.1, and the supporting references therein, fail to provide sufficiently detailed plan and profile information about the proposed Caliente rail alignment to support the impact findings reported in RA FEIS Chapter 4 and incorporated by reference in the Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") at FSEIS at 6-1 and 6-32. This deficiency is significant because, without sufficiently detailed rail alignment plan and profile information, the impact findings reported in RA FEIS Chapter 4, incorporated by reference in FSEIS Chapter 6, cannot be verified, and thus the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

Rail Alignment FEIS Subsection 2.2.1, and the supporting references therein, fail to provide sufficiently detailed plan and profile information about the proposed Caliente rail alignment to support the impact findings reported in RA FEIS Subsections 4.2.2 (Land Use and Land Ownership), 4.2.3 (Aesthetic Impacts), 4.2.5 (Surface Water Resources), 4.2.6 (Groundwater Resources), 4.2.7 (Biological Resources), 4.2.11 (Utilities, Energy, and Materials), 4.2.13 (Cultural Resources), and 4.2.14., all of which are incorporated by reference in the FSEIS at 6-1 and 6-32.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply

to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

In comments filed on the Draft Rail Alignment FEIS, Nevada pointed out the failure to present detailed rail alignment design maps and plan views:

> The Draft Rail Alignment EIS fails to provide the detailed information on proposed rail alignments necessary for the assessment of impacts required under NEPA. Specifically, DOE has failed to present detailed rail alignment design maps and plan views, including vertical profiles, for the Caliente and Mina preferred alignments and alternative segments.

(State of Nevada Comments on DOE's Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada-Nevada Rail Transportation Corridor – DOE/EIS-0250F-S2DE and DOE's Draft Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada – DOE/EIS-03690 (01/09/2008), LSN# NEV000004904 at 5-6.)

In the Rail Alignment FEIS Comment Response Document, Section 3.1 at CRD3-12, DOE states: "Detailed vertical profile drawings are provided in the Plan and Profile Drawings (DIRS 182674-Nevada Rail Partners, 2007, all; DIRS 180871-Nevada Rail Partners 2007, all)." However, DIRS 182674, Engineered Plan & Profile Drawing Set Caliente Rail Corridor, Task 6: Route Alignment Definition (ACC: ENG.20070606.0025 which is not on the LSN) is problematic in several respects:

- The technical acceptance date is May 15, 2007, which raises concerns about the extent to which it was actually used in preparation of the Draft RA EIS that was released in October 2007;
- DOE failed to post this reference on the Draft RA EIS reference website, or otherwise provide this document to Nevada and other stakeholders in time for review of the Draft RA EIS;
- DOE did not disclose this document until the RA FEIS was released in June 2008;

- The contents of DIRS 182674, 11" x 17" cut sheets, appear to be Microstation generated outputs which may or may not have been ground-proofed, and are marked "conceptual and not intended for construction;" and
- The level of detail, particularly regarding the top of rail elevations, is not sufficient to provide the information required for detailed location-specific, impact assessment.

Detailed information on the vertical profile of the finished track-bed structure is critical for assessing impacts on humans, livestock, and wildlife. The top of rail elevation above the adjacent land surface and the width and slope of the ballast shoulders are essential for determining the extent to which the railroad presents a barrier to movement at any specific location along the alignment.

Without detailed plan and profile drawings, potentially affected individuals and other reviewers cannot accurately determine the impacts of rail construction and operation on privately owned and leased lands traversed by the alignment. Without detailed plan and profile drawings, reviewers cannot determine whether or not the proposed alignments comply with the design parameters established by DOE. Without detailed plan and profile drawings, reviewers cannot independently verify the cut and fill requirements, the sub-ballast and ballast requirements, the right of way requirements, the disturbed area estimates, other major project attributes, and the resulting construction costs and impacts.

Rail Alignment FEIS, Subsection 2.2.1, and the supporting references DIRS 180916 and 182674, fail to provide a sufficiently detailed engineering design for the proposed Caliente rail alignment to support the impact findings reported in RA FEIS Chapter 4 and incorporated by reference in the FSEIS at 6-1 and 6-32. The information lacking includes accurate plan and profile information and cross sections. The lack of this critical information makes it extremely difficult, if not impossible, to accurately assess the impacts of the proposed rail line. Numerous design issues remain unresolved in these reports. Resolution of these issues will undoubtedly result in some significant changes to the proposed rail line, either through change in the profile or in relocation of the proposed centerline of the rail line to avoid the problems raised by the design issues (Richard C. Moore, PE, "Evaluation of Alignment Development Report and Engineered Plan and Profile Drawing Set, Caliente Rail Corridor" (12/03/2008), LSN# NEV000005456, all).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the sufficiency of the plan and profile information about the proposed Caliente rail alignment necessary to support the impact findings reported in RA FEIS Chapter 4 and incorporated by reference in the FSEIS at 6-1 and 6-32. In the RA FEIS Comment Response Document, Section 3.6.2 at CRD3-81, regarding Nevada Rail Line Design, DOE asserts, "The design criteria DOE used to develop the Proposed Action results in a level of design appropriate to evaluate the environmental impacts of proposed railroad construction and operation." DOE further asserts, "Highly specific details of a final design are not needed because available information is adequate to support DOE’s analyses of the potential impacts of the Proposed Action and a reasoned choice among alternatives." *Id.*

This deficiency is significant because without sufficiently detailed rail alignment plan and profile information, the impact findings reported in FSEIS Chapter 4, incorporated by reference in FSEIS Chapter 6, cannot be verified, and thus the FEIS and FSEIS cannot be adopted by the NRC.

NEV-NEPA-07 - OVERWEIGHT TRUCKS

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.1.6, regarding use of overweight trucks for shipment of legal-weight truck casks, fails to systematically assess the impacts of using overweight trucks for spent fuel shipments to Yucca Mountain, nationally and in Nevada. This failure is significant because without assessing the impacts of using overweight trucks for spent fuel shipments DOE has failed to adequately assess their environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS and the "Final Environmental Impact Statement for a Rail Alignment," DOE/EIS 0369 (06/2008), LSN# DEN001593557 ("FEIS"), neither document can be adopted by the NRC.

2. A brief summary of the basis for the contention

FSEIS Subsection 6.1.6 regarding use of overweight trucks for shipment of legal-weight truck casks fails to systematically assess the impacts of using overweight trucks for spent fuel shipments to Yucca Mountain, nationally and in Nevada. DOE provides contradictory evidence on the expected radiation exposures to workers, based on studies prepared in 1987 and 1993 (*see* FSEIS at 6-5 through 6-8), and DOE provides no analyses of the radiological impacts to safety inspectors and to members of the general public compared with use of legal-weight trucks.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply

to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The FSEIS proposal to use overweight trucks (OWT) contradicts previous DOE documents (*see* "Nuclear Waste Policy Act (Section 112) Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada, Volumes I, II and III" (05/01/1986), LSN#: DEN001427023, DEN001445346, and DN2002494035, all; "Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Readers Guide and Summary, Volume I, Volume II and Volume III" (02/01/2002), LSN#: DN2001688308, DN2002068024, DN2002488342, DN2002079298, DN2002139211, and DN2002140937, all; "OCRWM Transportation System Concept of Operations, DOE/RW-0584 Rev. 0" (04/03/2006), LSN# DN2002496829, all; "OCRWM National Transportation Plan, Pre-Decisional Draft" (07/16/2007), LSN# NEV000005471, all) that assume use of legal-weight trucks (LWT) for non-rail shipments, without systematically examining the potential impacts of using overweight trucks. This proposal creates a significant environmental impact because DOE anticipates making 2,650 to 5,025 truck shipments over 50 years (*see* FSEIS Table 8-13 at 8-41), and the average truck shipment distance for commercial SNF would be approximately 1,950 miles (*see* FSEIS Table G-8 at G-14).

The representative truck routes shown in the FSEIS Figure G-1 at G-7 indicate that OWT shipments could traverse 10-12 states on a single, one-way, loaded trip to Yucca Mountain. The FSEIS acknowledges that OWT shipments would be complicated by state permit requirements, but fails to estimate the increased stop times and shipment times likely to result from state permit requirements, including, but not limited to, port of entry inspections, random en route inspections, and route restrictions. DOE provides contradictory evidence that OWT use could result in either a 13 percent decrease or a 12 percent increase in worker radiation exposures (FSEIS Section 6.1.6 at 6-8) and DOE provides no specific analyses of the radiological impacts to safety inspectors and to members of the general public, compared with use of legal-weight trucks. DOE ignores the potential safety and security impacts of more frequent and possibly longer stops, which could increase opportunities for accidents, terrorism, and sabotage. (Because DOE has not suggested use of OWT for the past 15 years, there is little relevant literature on this topic.)

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

There is a genuine dispute between the State of Nevada and DOE regarding the FSEIS assessment of the impacts of using overweight trucks for spent fuel shipments. DOE appears to have ignored the comments Nevada filed on the DSEIS.

This deficiency is significant because, without full consideration of the impacts of using overweight trucks, there is no adequate evaluation of environmental impacts as required under NEPA. Because those environmental impacts could be materially different from that presented in the FSEIS and the FEIS, neither document can be adopted by the NRC.

NEV-NEPA-08 - IMPACTS ON AESTHETIC RESOURCES

1. A statement of the contention itself

Final Environmental Impact Statement for a Rail Alignment, DOE/EIS 0369 (06/2008) ("Rail Alignment FEIS" or "RA FEIS") Subsections 4.2.3, C.4.1.3, and D.1, regarding Caliente rail alignment aesthetic resources, fail to acknowledge unacceptable adverse impacts on a cultural resource of national and international significance, and fail to apply avoidance as the appropriate method of eliminating an unacceptable adverse impact that cannot be mitigated. The impact findings reported in Rail Alignment FEIS, Chapter 4, are incorporated by reference in Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Chapter 6. This deficiency is significant because without appropriately considering rail alignment impacts on aesthetic resources DOE has failed to adequately assess their environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS and the RA FEIS, neither document can be adopted by the NRC.

2. A brief summary of the basis for the contention

Rail Alignment FEIS Subsections 4.2.3 and D.1 fail to acknowledge a unique local condition of unacceptable adverse impacts – i.e., the existence in Garden Valley of a nationally and internationally acclaimed artwork, the land sculpture installation "City" by Michael Heizer, that would be irreparably harmed by construction of DOE's preferred segment (GV-3) or by any of the nearest three alternatives (GV-1, GV-2, and GV-8). DOE supports selection of segment GV-3 by defective viewshed simulations and analyses in RA FEIS Subsection D.1. DOE fails to adopt reasonable alternative rail alignment segments (GV-4, GV-5, or GV-7), identified in RA

FEIS Subsection C.4.1.3, that would avoid or significantly reduce adverse impacts on the "City" installation.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). In addition, as the federal agency charged with preparing the environmental impact statement, DOE has the primary and nondelegable responsibility to complete that task. *See*

Greene County Planning Board v. FPC, 455 F.2d 412, 420 (2d Cir.), *cert. denied*, 409 U.S. 849 (1972); and *Washington Utilities & Transp. Com. v. FCC,* 513 F.2d 1142, 1167 (9th Cir.), *cert. denied, sub nom., National Assoc. of Regulatory Utility Commissioners v. FCC,* 423 U.S. 836 (1975). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

DOE apparently failed to discover the existence of "City" until after publication of the Yucca Mountain DEIS in 1999, although DOE began studying a potential rail corridor through Garden Valley about 1990. At that time Michael Heizer had been constructing the installation for about 18 years. As early as 1985 the location was indicated on the USGS 7.5' Quadrangle map of the area by symbols entitled "sculpture." *See* "United States Department of the Interior Geological Survey, Water Gap West Quadrangle, Nevada, 7.5 Minute Series (Topographic)" (1985), LSN# DN20000393609. The installation was described in a major 1999 article in the *New York Times Magazine*. *See* M. Kimmelman, "A Sculptor's Colossus of the Desert," *New York Times Magazine* (12/12/1999).

After discovering the existence of "City," DOE continued to ignore its significance as a cultural resource. One of the sponsoring foundations informed DOE in 2004:

> To date, over $20 million has been spent and the project is 60% completed. In addition, once the sculpture is finished, visitors to the artwork and local employment for the maintenance of the project will have a positive ongoing effect on the local economy. Construction of a rail line in the Caliente corridor, as it is currently located, would lead to termination of the project's economic benefits to

> the surrounding communities. These socioeconomic impacts were not identified in the FEIS, and DOE did not consider them before stating a preference for the Caliente corridor.

"M. Govan Comment Responding to DOE Decision to Designate the Caliente Corridor as Preferred" (01/28/2004), LSN# DN2000524151 at 2. *See also*, "M. Govan Supplemental Comments Regarding Rail Alignment to the Yucca Mountain Repository" (05/28/2004), LSN# NEV000005475 at 1-2.

In 2005 the Association of Art Museum Directors (AAMD), representing 168 Museums in North America, designated "City" as an artwork "of national and international significance." *See* "M. Gaudieri, AAMD Press Release" (02/07/2005), LSN# NEV000005474 solo page. The potential impacts of the proposed Caliente rail line on City were further addressed in a second *New York Times Magazine* article, which included a picture of Michael Heizer and City on its front cover, in 2005. *See* M. Kimmelman, "Art's Last Lonely Cowboy," *New York Times Magazine* (02/06/2005).

In the RA FEIS Comment Response Document, DOE continues to deny that "City" is a cultural resource:

> The City sculpture is a work in progress and has not been identified as a cultural resource. Although resources younger than 50 years have occasionally been determined significant under special circumstances, the City sculpture has not been so evaluated.

RA FEIS Comment Response Document Section 3.7.10, at CRD3-223. Despite comments to the contrary submitted to DOE during review of the Draft RA EIS, DOE continues to argue in RA FEIS Subsections 4.2.3.2.2.3 at 4-87 and 4-88, and Table 4-35 at 4-99, that visual impacts would be "small to large, but temporary" during construction and "small" during railroad operations. Regarding noise impacts, DOE ignored comments about noise impacts at key observation points and responded that NEPA only "requires noise analysis where people sleep." RA FEIS

Comment Response Document Section 3.7.10 at CRD3-222. Thus, DOE completely dismissed the view of the museum directors: "Rail construction and operation will permanently destroy a visitor's experience of Heizer's isolated sculpture by causing irrevocable harm to the Valley's undisturbed emptiness and the silence of its delicate desert environment." (NEV000005474) The museum directors also point out: "Alternative rail routes have already been identified that would enable DOE to avoid Garden Valley." (NEV000005474)

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the classification of "City" as a cultural resource, the adverse impacts of rail construction and operation on "City," and the irreparable nature of the impacts which can only be mitigated by selecting an alternative alignment segment which avoids Garden Valley.

The deficiencies in DOE consideration of these matters are sufficient in and of themselves to prevent NRC from adopting the FEIS and FSEIS.

NEV-NEPA-09 - TRANSPORTATION SABOTAGE RISK VS. AT-REACTOR STORAGE

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.3.4 and Appendix G.8, regarding transportation sabotage events, describe what DOE considers to be reasonably foreseeable sabotage events involving repository shipments in urban areas that could result in radiological consequences. FSEIS Subsection 2.2, the No-Action Alternative, fails to consider reasonably foreseeable sabotage events at one or more of the 76 identified commercial reactor or DOE storage sites. This deficiency is significant because, without equally considering reasonably foreseeable sabotage events under both the Proposed Action and the No-Action Alternative, DOE has failed to adequately assess their environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS the document cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

In the FSEIS, DOE evaluated transportation sabotage event scenarios in urban areas, involving rail and truck casks loaded with commercial spent fuel, in which a weapon or device (also referred to as a high-energy-density device) was assumed to penetrate the cask and disperse its contents; however, FSEIS Subsection 2.2 has not evaluated a comparable, reasonably foreseeable sabotage event at one or more of the 76 identified commercial reactor or DOE storage sites.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

Under NEPA, the NRC must compare the Proposed Action to the No-Action Alternative. However, the FSEIS does not consider at all the consequences of a sabotage event under the No-Action Alternative, and has not considered the full benefits of storing spent nuclear fuel at reactor sites under the No-Action Alternative. The effect has been to bias the cost/benefit analysis towards the Proposed Action.

Nevada has prepared a detailed estimate of the radiological consequences of a successful sabotage event at a commercial reactor storage site, and concluded that the radiological consequences resulting from an attack on a storage cask at a commercial reactor site are far less than those resulting from a successful attack on a transportation cask in an urban area. *See* "Diablo Canyon Environmental Assessment Supplement" (06/27/2007), LSN# NEV000005457, all. The Nevada storage sabotage analysis assumed that a spent fuel storage cask was penetrated by a military shaped-charge weapon. *Id*.

Moreover, the FSEIS discussion of the No-Action Alternative fails to consider the benefits of extended storage at a commercial reactor site, because of the resulting fission product decay the impacts of off-site transportation at some future date would be reduced. The comparison of extended storage to the Proposed Action is especially relevant because DOE has proposed shipping very hot, high-burn up spent nuclear fuel in the TAD canister transportation system. Nevada has evaluated the radiological characteristics of the reference PWR spent fuel evaluated by DOE in the FSEIS, and compared its characteristics to spent fuel cooled for 50 years. *See* Halstead, R.J., *et al.*, "State of Nevada Perspective on the U.S. Department of Energy Yucca Mountain Transportation Program-8154, Waste Management ’08" (02/29/2008), LSN# NEV000005266 at 7-8. Since the TAD design specifications would allow shipments of PWR fuel with burn up greater than 70,000 MWDt/MTHM, and as little as 5 years cooling time, such fuel would be thermally hotter and more radioactive than the DOE representative PWR fuel (i.e., 4.2% initial enrichment, burn up 60,000 MWDt/MTHM, 10 years cooling time), which has a surface dose rate in excess of 35,000 rem/hour that is capable of producing an unshielded lethal exposure in 1-2 minutes. After 50 years cooling, compared to 5 years cooling, the DOE reference PWR fuel would exhibit a 65 percent reduction in the inventory of Cs-137, a 75 percent reduction in total radionuclide activity, and an 85 percent reduction in surface dose rate. *Id*. The FSEIS does not evaluate the impacts of shipping the higher burn up fuel specified in the TAD designs. The FSEIS also does not evaluate the radiological implications of shipping 5-year-cooled spent fuel, compared to older fuel. Finally, storage of spent nuclear fuel at reactor sites for a period of 100 years, the FSEIS No-Action Alternative, reduces the consequences of a sabotage event at the reactor site, or in the event of an off-site transportation sabotage event or accident, by a factor of 10. After 100 years cooling versus the DOE representative 10 years cooled PWR fuel (4.2% initial enrichment, burn up 60,000 MWDt/MTHM), the radionuclide inventory is reduced by a factor of 10. This is due to fission product decay, particularly regarding Cs-137 (half-life 30.0 years) and Sr-90 (half-life 29.1 years). *Id*.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the consequences of a sabotage event during extended at-reactor storage under the No-Action Alternative, compared with the consequences of a sabotage event involving a spent fuel shipment at an urban location under the Proposed Action. Nevada and DOE further dispute the overall benefits of extended at-reactor storage under the No-Action Alternative, resulting from fission product decay and reduction in transportation impacts, compared to the Proposed Action.

NEV-NEPA-10 - LONG-TERM RADIATION EXPOSURE FOLLOWING SABOTAGE

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.3.4.2 and Appendix G.8 regarding transportation sabotage events, and Appendix G.9.7 regarding cost of cleanup after accidents, fail to provide a realistic estimate of population radiation doses and the cost of cleanup following a sabotage event. Since insurance coverage available under the Price-Anderson Act (Section 170 of the Atomic Energy Act of 1954, as amended) would be inadequate, Congress would have to supplement the cleanup costs. Also, the period of cleanup could be greater than one year, implying an increase in radiation exposure over that assessed by DOE. This deficiency is significant because, without considering a reasonable cost of cleanup following a sabotage event, DOE has failed to adequately assess its environmental impact, and because that environmental impact could be materially different from that presented in the FSEIS, the document cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

The FSEIS fails to estimate costs of cleanup following any of the transportation sabotage events evaluated by DOE, despite the DOE assumption that cleanup would occur and despite the availability of computer models developed for DOE that can provide estimates of cleanup costs for such events. Under alternative release scenarios, the cleanup costs will greatly exceed the limits of Price-Anderson Act implying Congress will have to provide additional funds, thereby lengthening the one-year cleanup period assumed in the FSEIS.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-

compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

In the FSEIS, DOE acknowledges the vulnerability of truck and rail shipping casks to various sabotage event scenarios, and estimates the potential public health impacts over a one-year period due to an attack that releases radioactive materials, but provides no estimate of the cost of clean up after such events. *See* FSEIS Subsection 6.3.4.2 at 6-26 through 6-31, and Appendix G.8 at G-48 through G-50. In FSEIS Section G.9.7, DOE discusses the cost of cleanup after transportation accidents, rejects the sabotage clean up cost estimates developed by Nevada as "unrealistically high," but provides no sabotage cleanup cost estimates of its own. Yet, FSEIS Subsection 6.3.4.2 at 6-24 states that after a sabotage incident resulting in a release, "DOE anticipates that . . . cleanup actions would be initiated."

Radioactive Waste Management Associates (RWMA) recently re-evaluated earlier cleanup cost estimates and prepared new estimates for a range of sabotage event scenarios. *See* Resnikoff & Travers ("Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008), LSN# NEV000005444, all). According to Resnikoff & Travers, cleanup costs following sabotage events similar to those evaluated by DOE in the FSEIS, in which the casks are penetrated but not perforated, could range from $3.5 billion to $45.8 billion (2008$). *Id*. Transportation sabotage events in which the casks are fully perforated could result in cleanup costs of $463 billion to $648 billion (2008$). *Id*. These latter dollar costs greatly exceed the insurance limits available under the Price-Anderson Act (covering damages caused to the public by an extraordinary nuclear event), which would require an act of the U.S. Congress to cover remaining costs. Any delay by the Congress or the President in enacting such legislation would likely extend the cleanup time beyond the one year exposure period considered by DOE when calculating population radiation doses, thereby increasing long-term radiation doses to exposed populations and even further increasing cleanup costs.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the realistic estimates of population radiation doses and cleanup costs following a transportation sabotage event evaluated in FSEIS Subsections 6.3.4 and Appendix G.8. DOE has failed to provide any sabotage cleanup cost estimates of its own in the FSEIS; therefore the NRC cannot estimate if a one year long-term exposure period is a realistic time frame for a radiation dose given to a population after a sabotage incident. Resnikoff & Travers (NEV000005444) has prepared new and updated cost estimates ranging from $3.5 billion (2008$) to $45.8 billion (2008$) for sabotage events similar to those evaluated in the FSEIS, and clean up costs of $463 billion to $648 billion (2008$) for more severe sabotage events.

NEV-NEPA-11 - SABOTAGE RISK, PRESSURIZED CASK

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS"), Subsections 2.1 and 2.2 compare the preferred alternative of disposing spent nuclear fuel at the proposed Yucca Mountain repository to the no-action alternative of storing spent nuclear fuel at commercial reactor sites, however, FSEIS Subsections 6.1.11 and 6.3.4.2 fail to properly account for cask pressurization in a sabotage event during transportation. The cost/benefit ratio is therefore biased towards the preferred alternative. This deficiency is significant because without appropriately considering a sabotage event during transportation, DOE has failed to adequately assess its environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS, the document cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

FSEIS Subsection 6.1.11 and 6.3.4.2, and references therein, fail to account properly for pressure within the internal canisters within transportation overpacks, which would increase the release of radioactive material during a sabotage event, and instead presume that blowdown is primarily due to cask pressurization from damaged fuel assemblies and not from pressurization of the cask itself.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply

to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>Statement of the facts or expert opinions supporting the contention along with appropriate citations to supporting scientific or factual materials</u>.

DOE in its FSEIS fails to realistically estimate the consequences of reasonably foreseeable sabotage attack scenarios. Specifically, FSEIS Subsection 6.3.4.2 at 6.3-27 and its reference document Luna (2006) (Luna, R.E. "Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack," WM'06 Conference, February 26-March 2, 2006, Tucson, Arizona: WM Symposia, TIC: 259643, all), use sabotage release fractions from an unpressurized cask, the only pressurization being due to the release of pressurized gas from damaged fuel assemblies. Luna (2006) is based on measurements in 1983 at Sandia and 1994 in Germany from unpressurized transportation casks. *See* "An Assessment of the Safety of Spent Fuel Transportation in Urban Environs," Sandia National Laboratories, SAND82-2365 (06/1983), LSN# DN2002413903, all; and Pretzsch, G. and Lange, F. (1994), "Experimental Determination of the Release of UO2 from a Transport Container for Spent Fuel Elements after Shaped Charge Bombardment," GESELLSCHAFT FUR ANLAGEN UND REAKTORSICHHEIT, GRS A-2157. Radioactive releases occurred in two stages: immediately and shortly thereafter due to blowdown from internal pressure. Since rail casks have a larger free volume than truck casks, the releases from rail casks were determined to be smaller, since the resultant cask pressure was lower. However, in reality, storage casks in use at reactor sites are pressurized with helium to an internal pressure of 100 psig. *See* Holtec International (1999), "Safety Analysis Report for the Holtec International Storage, Transport and Repository Cask System (HI-STAR 100 Cask System) (excerpt from NRC Docket No. 71-9261, Volume 1)" LSN# NEV000005473, Table 1.2.3 at 1.2-27. When punctured by an explosion, the blowdown effect would be far greater with a pressurized cask than assumed in the FSEIS and Luna (2006).

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between Nevada and DOE regarding the effect of cask pressurization on the release of radioactive materials. DOE, based on the release fractions from Luna (2006), does not consider the cask to be initially pressurized. The State of Nevada does consider the cask initially pressurized. Recent documentation ("Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008), LSN# NEV000005444, all) supports that, in a potential sabotage event, the consequences would be greater for a pressurized cask. This deficiency is significant because, without considering reasonably foreseeable attack scenarios, there is no adequate disclosure of alternatives under NEPA. If reasonable alternatives were added, the disclosure of radiological impacts could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

NEV-NEPA-12 - TRANSPORTATION RISK ASSUMPTIONS

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.3 regarding national transportation events, and Appendices G.6 through G.8, specifically regarding transportation event assumptions, fail to use the consistent application of weather and release fraction assumptions to all reasonably foreseeable accident and sabotage scenarios. This deficiency is significant because, without the consistent application of weather and release fraction assumptions to transportation accident or sabotage events, DOE has failed to adequately assess their environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS and the "Final Environmental Impact Statement for a Rail Alignment," DOE/EIS 0369 (06/2008), LSN# DEN001593557 ("Rail Alignment FEIS" or "RA FEIS"), neither document can be adopted by the NRC.

2. A brief summary of the basis for the contention

In FSEIS Subsections 6.3.3 and 6.3.4, DOE evaluates reasonably foreseeable transportation accidents and sabotage events but has inconsistently applied weather and release fraction assumptions when evaluating the consequences of these transportation scenarios without any explanation for the inconsistencies.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply

to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The FSEIS fails to consistently apply weather and release fraction assumptions when evaluating the consequences of transportation accidents and sabotage events. To evaluate transportation accidents and sabotage events, DOE uses Pasquill Stability Class D and release fractions from 26 fuel assemblies in a rail cask. *See* FSEIS Appendix G.6.1.3 at G-43 and Appendix G.8 at G-49. However, to evaluate the maximum reasonably foreseeable transportation accident, DOE uses Pasquill Stability Class F and release fractions from a rail cask containing 21 fuel assemblies. *Id*., Appendix G.7 at G-47. The use of different weather and release fractions between these evaluations is an inconsistent application of assumptions. DOE does not consider the maximum reasonably foreseeable accident scenario since it assumes Pasquill category F, but with a cask containing 21 PWR fuel assemblies; DOE does not consider the maximum reasonably foreseeable sabotage scenario since it considers a cask containing 26 PWR fuel assemblies, but with Pasquill category D.

In the FSEIS, DOE argues that it does not need to consider Pasquill Stability Class F when evaluating sabotage events because it does not need to consider "remote" or "highly speculative" consequences. *See* FSEIS Section 6.3.4.2 at 6-31. However, DOE does not define the terms "remote" or "highly speculative." On annual average, Pasquill Stability Class D is observed to occur 47 percent of the time and Pasquill Stability Class F 21 percent of the time. *See id*., Appendix G.6.1.3 at G-44. That is, Category D is only slightly more than twice as likely as Category F. Aside from Pasquill Stability Class D, Pasquill Stability Class F occurs more often than any other Pasquill Stability Class. Due to the high annual average occurrence of Pasquill Stability Class F, there is no basis to consider Pasquill Stability Class F a "remote" or "highly speculative" occurrence. Consequences of reasonably foreseeable transportation accidents and sabotage events are much higher under Pasquill Stability Class F. *See* "Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: Updated Analysis Revised Final Version" (11/01/2008), LSN# NEV000005444, all. *See also* "Halstead Spreadsheet Calculating Population Exposures When Meteorology is Changed from Pasquill Category D to Pasquill Category F" (11/21/2008), LSN# NEV000005464, solo page. Therefore, DOE did not consider the maximum reasonably foreseeable sabotage scenario in the FSEIS and does not comply with NEPA requirements.

Realistically, transportation rail casks will contain between 21 and 26 fuel assemblies per cask. Many casks used for dry storage at reactor sites contain 26 PWR fuel assemblies. The maximum reasonably foreseeable rail accident should therefore account for release fractions from 26 PWR fuel assemblies. DOE does not consistently apply release fraction assumptions from a rail cask containing 26 fuel assemblies in its evaluation of the maximum reasonably foreseeable transportation accident, nor does it consider a maximum reasonably foreseeable transportation sabotage event involving release fractions from 26 fuel assemblies and Pasquill Stability Class F.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the inconsistent application of weather and release fraction assumptions in the evaluation of transportation accidents and sabotage events in the FSEIS. DOE has failed to consistently apply the same weather and release fraction assumptions to all accident and sabotage scenarios, which would greatly increase the consequences of these scenarios.

NEV-NEPA-13 - GRAZING IMPACTS

1. <u>A statement of the contention itself</u>

Final Environmental Impact Statement for a Rail Alignment, DOE/EIS 0369 (06/2008) ("Rail Alignment FEIS" or "RA FEIS") Subsections 4.2.2.2.3.2 and 4.3.2.2.3.2, incorporated by reference in Section 6.4 of the Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") (*see* FSEIS at 6-1), acknowledge that DOE failed to apply the appropriate methodology in assessing the impacts of railroad construction on up to 32 active Bureau of Land Management (BLM) grazing allotments. This deficiency is significant because, without accurately assessing impacts of railroad construction on grazing allotments, there is no adequate disclosure of alternatives under NEPA. If reasonable alternative corridors, alignments, and segments were assessed, the disclosure of impacts on grazing allotments could be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

2. <u>A brief summary of the basis for the contention</u>

Rail Alignment FEIS Subsection 4.2.2.2.3.2 acknowledges that DOE applied an inappropriate, generic methodology, based on a simple percentage of the allotment acreage withdrawn for the railroad right-of-way and associated ballast quarries, to estimate the potential loss of animal unit months for up to 20 active grazing allotments along the proposed Caliente rail alignment. "The Department did not consider site-specific allotment characteristics." (RA FEIS at 4-46.) DOE attempts to justify this deficient methodology by asserting that "actual loss of animal unit months for each affected allotment" would be determined at a future date by BLM. (*Id*. at 4-47.) The RA FEIS used the same inappropriate method for assessing impacts of railroad construction on up to 12 active grazing allotments along the proposed Mina rail alignment. (RA FEIS at 4-443.)

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). In addition, as the federal agency charged with preparing the environmental impact statement, DOE has the primary and nondelegable responsibility to complete that task. *See*

Greene County Planning Board v. FPC, 455 F.2d 412, 420 (2nd Cir.), *cert. denied*, 409 U.S. 849 (1972); and *Washington Utilities & Transp. Com. v. FCC,* 513 F.2d 1142, 1167 (9th Cir.), *cert. denied, sub nom., National Assoc. of Regulatory Utility Commissioners v. FCC,* 423 U.S. 836 (1975). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The Rail Alignment Draft EIS failed to appropriately evaluate impacts of the proposed rail alignments on BLM grazing allotments. Richard Moore, P.E., prepared detailed comments on the Draft EIS for the State of Nevada and submitted the following comments to DOE. *See* "Yucca Mountain Issue Urgent! Comments RRR000784 through RRR000979 for Draft SEIS" (1/10/2008), LSN# DEN001586806 at 249-250:

> DOE has not accurately assessed the impact that construction and operation of the proposed rail line will have on grazing allotments in Nevada. DOE calculated the impact on grazing allotments by "quantifying" the amount of forage lost. This loss of forage was then converted to animal unit-months (AUM) for each grazing allotment, based upon the "footprint" of the rail line in proportion to the total area of the grazing allotment. (DEIS p. 4-44) DOE did not base the loss of animal unit-months on site-specific data. Yet, DOE acknowledges that factors that influence how many animal unit-months land can support include the quantity and quality of forage, type of forage, season in which the forage will be grazed, soil, *etc.* (DEIS p. 4-269) DOE then goes on to dismiss the loss of forage as insignificant, because it compares the dollar value of the lost AUM's in terms of the total economy for Nye and Lincoln Counties. Finally, DOE does note that "individuals and localized areas could feel the impacts more severely." (DEIS p. 4-270)
>
> To accurately assess the impact on grazing allotments, site-specific data is essential. Much of this data is currently available through the Bureau of Land

Management (BLM), who determines how many AUM's are allowed on an allotment based upon available forage. It is important to note that the location of the rail bed to local topography is also a critical factor in determining the loss of forage. Nevada is an arid state. Most drainages are ephemeral, flowing only in response to precipitation events. Most of these events do not provide enough rainfall to cause streams to flow. Rather, as the precipitation comes down, water runs down the side slopes of drainages, soaking into the bottom lands, replenishing soil moisture in these locations. Thus, the "bottom lands" of ephemeral drainages have the most abundant forage, with less and less forage available as you climb up slope.

The rail line will preferentially be located in these same bottom lands. Thus, the construction of the rail line takes the most productive land out of production.

DOE also does not accurately reflect the length of time that forage lost due to construction impacts will be unavailable, assuming that once operations begin, there is no loss of forage. This must be based upon the erroneous assumption that reclamation of disturbed areas will occur quickly. However, in an arid environment such as Nevada, it will take many years, if ever, for the reclaimed land to reach the same level of production of forage.

The rail bed will also create an obstruction to water flow. DOE notes that "the cut and fill operations during rail line construction would cause the alteration of natural drainage patterns and runoff rates in some areas that could affect downgradient resources" (DEIS p. 4-125) In fact, the replenishment of soil moisture in bottom lands would be eliminated, resulting in much less forage productivity in areas downgradient of the rail line. Therefore, not only is forage production reduced over the life of the project, but it is also reduced over a much greater area than DOE calculated.

DOE should accurately calculate forage loss, and the resulting economic impact on the ranchers who use the grazing allotments. Individual ranchers could be severely impacted. That impact, in turn, could have significant impacts on the local economies of the small towns in this sparsely populated area.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the potential impacts of railroad construction on active BLM grazing allotments. Nevada believes that construction impacts on individual grazing allotments must be assessed considering site-specific characteristics, and the assessment must be conducted by DOE in the present Rail Alignment EIS in order to allow comparison of impacts associated with reasonable alternative rail corridors, alignments, and segments. DOE acknowledges that consideration of site-specific characteristics could result in greater losses of forage and greater losses of animal unit months, than estimated in the Rail Alignment FEIS, but DOE defers actual evaluation of these impacts until some future date following a DOE request for a BLM right-of-way grant. (RA FEIS at 4-46 to 4-47.)

NEV-NEPA-14 - DEFERRED ASSESSMENT OF RAILROAD CONSTRUCTION IMPACTS ON GRAZING

1. A statement of the contention itself

"Final Environmental Impact Statement for a Rail Alignment," DOE/EIS 0369 (06/2008), LSN# DEN001593557 ("Rail Alignment FEIS" or "RA FEIS") Subsections 4.2.2.2.3.2 and 4.3.2.2.3.2, incorporated by reference in Section 6.4 of the Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") (*see* FSEIS at 6-1) illegally defer assessment of impacts of railroad construction on individual BLM grazing allotments to a future action by the Bureau of Land Management (BLM). DOE has no authority to transfer its NEPA responsibilities to BLM, and DOE has no authority to assign to BLM the responsibility for mitigation of impacts resulting from DOE's proposed action. If the appropriate assessment and disclosure of railroad construction impacts on individual grazing allotments is deferred, the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

Rail Alignment FEIS Subsections 4.2.2.2.3.2 and 4.3.2.2.3.2 acknowledge that DOE applied an inadequate methodology to estimate the potential loss of animal unit months for up to 32 active grazing allotments along the proposed Caliente and Mina rail alignments. "The Department did not consider site-specific allotment characteristics." (RA FEIS DEN001593557 at 4-46.) DOE attempts to justify this deficient methodology by asserting that "actual loss of animal unit months for each affected allotment" would be determined at a future date by BLM after DOE requests a BLM right-of-way grant for the alignment selected by DOE. (RA FEIS DEN001593557 at 4-47.)

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). In addition, as the federal agency charged with preparing the environmental impact statement, DOE has the primary and nondelegable responsibility to complete that task. *See Greene County Planning Board v. FPC,* 455 F.2d 412, 420 (2d Cir.), *cert. denied*, 409 U.S. 849 (1972); and *Washington Utilities & Transp. Com. v. FCC,* 513 F.2d 1142, 1167 (9th Cir.), *cert.*

denied, *sub nom., National Assoc. of Regulatory Utility Commissioners v. FCC,* 423 U.S. 836 (1975). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

The Rail Alignment Draft EIS (LSN# DEN001593557) acknowledges that DOE failed to appropriately evaluate impacts of the proposed rail alignments on BLM grazing allotments. DOE proposes a novel and potentially illegal division of NEPA authority between DOE and BLM. DOE also proposes an inappropriate and potentially illegal segmentation of impact assessment, selection of a preferred alternative, and mitigation of impacts resulting from the proposed action.

DOE provides a compelling critique of its own deficient assessment of impacts in the RA FEIS (DEN001593557 at 4-46):

> In fact, this calculation method assumes that there is uniform forage distribution across the entire allotment, which would be unlikely. Because the proposed rail line would generally follow flatter terrain, such as valley floors (due to grade limitations of the railroad), the rail alignment would likely transect those areas that typically sustain a greater proportion of high-quality forage. Furthermore, where the rail line would bisect allotments or isolate portions of allotments or pastures, additional land and possibly water features such as springs may be inaccessible for grazing and there could be substantially greater losses of animal unit months unless mitigation measures are employed.

DOE's proposed remedy to its defective first action, the proper assessment and mitigation of impacts by BLM at a later date, is unacceptable and potentially illegal. First, DOE proposes to select the preferred rail alignment based on an admittedly deficient impact assessment methodology, to be followed by proper impact assessment and mitigation by another agency. This sequencing of events clearly prevents the comparative evaluation and disclosure of alternatives required under NEPA. Second, DOE ignores its own primary role as the creator of adverse impacts on grazing operations. The adverse impacts on individual grazing allotments will result from DOE's proposed action, construction of the rail line, and not from BLM's granting DOE a construction right-of-way. Third, DOE has no authority to ensure that BLM actually implements the mitigation measures described in Chapter 7 of the RA FEIS, nor does DOE estimate the costs of providing mitigation, or address which if any agency will actually be responsible for the cost of mitigation and compensation. Fourth, if as DOE concedes, "further consultation with the STB" may be necessary to manage impacts of constructing and operating the railroad (RA FEIS at 7-4), surely these "additional practices and measures" (*id.*) should be considered as part of the evaluation of alternatives during the NEPA process and not afterwards. In its application to STB for a Certificate of Public Convenience and Necessity for the Caliente rail line, DOE's own cost reference document states that its estimated construction cost does not include "costs to mitigate impacts." (LSN# DEN001593557 at CRD3-62, citing "Nevada Rail Partners 2007: Comparative Cost Estimates, Caliente Rail Corridor Summary Report, Task 17: Cost Estimating Support, Rev. 00" (2007), ENG.20070724.0017 at 13). Nor does DOE address mitigation and compensation costs in Chapter 7 of the RA FEIS.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the evaluation of potential impacts of railroad construction on active BLM grazing allotments. Nevada believes that construction impacts on individual grazing allotments must be assessed considering site-specific characteristics, and the assessment must be conducted by DOE in the present Rail Alignment EIS in order to allow comparison of impacts associated with reasonable alternative rail corridors, alignments, and segments. DOE acknowledges that consideration of site-specific characteristics could result in greater losses of forage and greater losses of animal unit months, than estimated in the Rail Alignment FEIS, but DOE defers actual evaluation of these impacts until some future date following a DOE request for a BLM right-of-way grant. (*See* RA FEIS DEN001593557at 4-46 to 4-47.)

NEV-NEPA-15 - TAD SHIPMENT ESTIMATES

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.1.7 and Appendix G.3, regarding shipment estimates that assume the use of transportation, aging and disposal ("TAD") canisters at commercial reactor sites, fail to consider reasonable shipment estimates based on the existing standard contracts and current modal capabilities of the shipping sites. Thus, the FSEIS fails to provide a sufficient basis for the transportation impacts estimated in Sections 6.3 and 6.4. In addition, the FSEIS fails to provide a basis for determining if DOE can comply with SAR Subsection 1.5.1.1, which presumes 90 percent of commercial spent nuclear fuel will be shipped in TAD canisters. Because DOE failed to consider reasonable shipment estimates, particularly regarding the modal mix between rail and truck, DOE has failed to adequately assess their environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS and the "Final Environmental Impact Statement for a Rail Alignment," DOE/EIS 0369 (06/2008), LSN# DEN001593557 ("Rail Alignment FEIS" or "RA FEIS"), neither document can be adopted by the NRC.

2. A brief summary of the basis for the contention

FSEIS Subsection 6.1.7 at 6-8 based shipment estimates "on 90 percent [by metric tons of heavy metal (MTHM)] of the commercial spent nuclear fuel being shipped in rail casks that contained TAD canisters. Shipment of the remaining 10 percent of the commercial spent nuclear fuel would be in rail casks that contained other types of canisters such as dual-purpose canisters or as uncanistered spent nuclear fuel in truck casks." SAR Subsection 1.5.1.1 at 1.5.1-8 requires DOE to demonstrate its capability to meet the 90 percent TAD threshold on an annual basis. The

FSEIS Appendix A.2 also provides a shipment estimate based on 75 percent of commercial spent nuclear fuel received in TAD canisters shipped by rail.

3. <u>A demonstration that the contention is within the scope of the hearing</u>

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental

costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The FSEIS Proposed Action is to ship 63,000 MTHM of commercial spent nuclear fuel to Yucca Mountain. Under the FSEIS base case shipment estimates, DOE asserts that it can transport 90 percent of the commercial spent nuclear fuel, or 56,700 MTHM, to Yucca Mountain in TAD canisters shipped in rail casks. According to the SAR Subsection 1.5.1.1 at 1.5.1-8, DOE annual shipments to the repository must be "at least 90%" in TAD canisters. A close examination of the data presented in the FEIS, the FSEIS, and other sources demonstrate that it is highly unlikely that DOE can achieve the 90 percent TAD compliance threshold for either total shipments or annual shipments of commercial spent nuclear fuel.

Even DOE acknowledges in FSEIS Appendix A.2.1 at A-3 that it cannot meet the 90-percent TAD objective. "In the 90-percent case, 88 percent of the commercial spent nuclear fuel would be shipped in rail casks containing TAD canisters, 5 percent would be shipped in rail casks containing dual-purpose canisters, and 7 percent would be shipped uncanistered in truck casks. These percentages are based on MTHM, not on the number of casks." (FSEIS at A-3)

The Nuclear Energy Institute ("NEI") currently estimates that there is about 58,000 MTHM of spent nuclear fuel in storage, of which about 10,500 MTHM is in dry storage at 40 sites. NEI further estimates that by 2017 about 22,300 MTHM of spent nuclear fuel will be in dry storage at 66 sites. *See* "NEI Dry Storage Information Forum Presentation, Steven P. Kraft, Nuclear Energy Institute, Used Nuclear Fuel Integrated Management" (05/13/2008), LSN# NEN000000384 at 2. The 10,500 MTHM already in dry storage means that about 16.7 percent of the total amount DOE plans to ship to the repository is already committed to storage systems that are not compatible with the TAD canister system. Even if DOE deploys TAD canisters by 2013, it is likely that another 5,900 MTHM or more will be committed to non-TAD dry storage systems. Thus, the best case is that about 16,400 MTHM, or 26 percent of the total commercial SNF inventory DOE plans to ship to the repository under the Proposed Action, would be committed to non-TAD dry storage systems before the earliest date for repository operations.

DOE's ability to meet the 90-percent TAD canister in rail cask objective for total repository shipments will also be limited by transportation interface challenges at reactors which currently lack rail access. In the FSEIS, DOE identifies 7 commercial reactor sites that would ship SNF by truck. *See* FSEIS at G-14. The 7 truck-shipping sites account for 4,524 MTHM, or about 7.2% of the commercial SNF shipped under the proposed action. *Id*. at A-15. The FSEIS also identifies 22 sites which would use heavy haul trucks, and in 17 cases possibly barges, to ship rail casks to the nearest railroad connection. *Id*. at G-14. These 22 sites account for 18,290 MTHM, or about 29.0 percent of the commercial SNF shipped under the proposed action. *Id*. at A-15. DOE has not demonstrated the ability of these sites to actually ship rail casks by heavy haul truck or by barge.

DOE's ability to meet the 90-percent TAD canister rail objective for annual shipments will further be limited by transportation interface issues at the reactors which currently hold early slots in the annual shipping allocations established under the standard contracts. The sites without direct rail access account for almost one-half (47.6 percent) of the spent fuel that DOE would likely ship to the proposed repository in the first five years of operation. The order of shipments derives from the allocation method employed in the standard contracts between DOE and the nuclear utilities. Based on the "oldest fuel first" method, DOE has established an acceptance priority ranking for receipt of commercial spent fuel, and has projected annual capacity allocations for the first ten years of repository operations. The annual acceptance allocations for years one to five, for the 23 sites that lack direct rail access, are a combined 3,432 MTHM, compared with total allocations for all shipping sites of 7,210 MTHM. ("Halstead and Dilger, Shipping Site Intermodal Transportation, Further Revised Draft" (12/11/2007), LSN# NEV000005460, all; "Halstead and Dilger, Shipping Site Intermodal Transportation, New Draft" (04/23/2008), LSN# NEV000005477, all.)

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

There is a genuine dispute between the State of Nevada and DOE regarding the FSEIS TAD-canister shipment estimates, specifically regarding DOE's ability to meet its self-imposed 90-percent TAD canister in rail cask objective for total repository shipments and annual repository receipts. The validity of DOE's shipment estimates is directly related to the FSEIS assessment of transportation impacts nationally and in Nevada, and is essential to DOE's ability to demonstrate compliance with SAR Subsection 1.5.1.1.

NEV-NEPA-16 - REPRESENTATIVE ROUTES

1. A statement of the contention itself

Final Supplemental Environmental Impact Statement for Yucca Mountain, DOE/EIS 0250S-F1 (07/2008) ("FSEIS") Subsection 6.3 and Appendices A.3 and G.2, regarding "representative routes" that DOE could use for shipments of spent nuclear fuel and high-level radioactive waste, fail to identify the affected environment for repository transportation impacts nationally and in Nevada. FSEIS Appendix A3 states that DOE used historic rail industry practices to estimate the representative rail routes that would be used under the Proposed Action. However, DOE's representative rail routes incorporate rail industry practices in only a generic way, and ignore information provided to DOE by potential rail carriers and by affected states about other potential rail routes, different from those identified by DOE, that could be used for repository shipments. This deficiency is significant because without appropriately considering specific impacts from specific rail routes, DOE has failed to adequately assess environmental impacts, and because those environmental impacts could be materially different from that presented in the FSEIS the document cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

The "representative rail routes" described by FSEIS Appendices A.3 and G.2 were estimated using a generic computer model that does not reflect specific recommendations made by the rail industry; and the routes are indicative of the insufficient analysis used by DOE to describe the transportation impacts of the proposed action.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), and 63.31(c), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts, including transportation impacts, of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

FSEIS Appendix A.3 at A-5 described the way in which DOE identified potential rail routes to Yucca Mountain:

> DOE used the TRAGIS computer program to generate the representative rail routes it used to estimate the transportation impacts in Chapter 6 and Appendix G of this Repository SEIS. These rail routes are called unconstrained because minimal constraints, or blocks, were not placed in the rail network. DOE based its identification of the representative national rail routes on historic railroad industry routing practices. The Department identified these routes by giving priority to the use of rail lines that have the most rail traffic, which are the best maintained and have the highest quality track; giving priority to originating railroads; minimizing the number of interchanges between railroads; and reducing the distance traveled.

While this model may be adequate for rough planning calculations, DOE is required under NEPA to provide specific information about its proposed action.

In 2005, the Union Pacific Railroad provided DOE with a map of the specific preferred routes it would likely use for repository shipments. "Union Pacific Rail Transportation, Presentation by Roger Dolson at DOE Transportation External Coordination Working Group Meeting, Pueblo, Colorado" (09/2005), LSN# NEV000005499 at 26. In 2005, the Midwest Council of State Governments identified preferred rail routes for shipments through Midwestern states. "The Council of State Governments' Midwestern Radioactive Transportation Committee, Route Identification Project: Final Report to the U.S. Department of Energy's Office of Civilian Radioactive Waste Management" (12/07/2005), LSN# NEV000005459 at 5-29. In 2006, the National Academy of Sciences published "Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States" (Committee on Transportation of Radioactive Waste, Nuclear and Radiation Studies Board, Transportation Research Board (2006) The National Academies Press, 500 Fifth Street NW, Lockbox 285, Washington, D.C. 20055) at 228-232, a report that urged DOE to precisely define the routes used to ship High-Level Radioactive Waste. In 2007, DOE issued its draft transportation plan ("OCRWM National Transportation Plan, Pre-Decisional Draft" (07/16/2007), LSN# NEV000005471 at 37) which implied that early selection of rail and truck routes was a goal of DOE. In 2008, the State of Nevada identified potential cross-country rail routes to Yucca Mountain that reflected preferences stated by potential rail carriers and incorporated DOE's internal policy of evaluating a "suite" of potential routes that could enhance shipment security. "State of Nevada Comments on DOE's Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada-Nevada Rail Transportation Corridor – DOE/EIS-0250F-S2DE and DOE's Draft Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada – DOE/EIS-0369D" (01/09/2008), LSN# NEV000004904 at 15-16.

Despite these requests for early action on route selection and identification, DOE has failed to analyze routes suggested by the railroads themselves and by the affected states. Instead, DOE has relied on a computer model that may or may not reflect the rail industry's preferences and intentions. As a result, DOE has not defined the proposed action or properly evaluated its impacts in any meaningful way. Therefore, DOE cannot answer the simple question: What route will the high-level radioactive waste use to travel to Yucca Mountain? As a result, the FSEIS has not adequately assessed the environmental impacts associated with the transportation of high-level radioactive waste to Yucca Mountain, and NRC cannot adopt it.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

There is a genuine dispute between the State of Nevada and DOE regarding the FSEIS identification of representative routes used to move the high-level radioactive waste and spent nuclear fuel to Yucca Mountain and the associated environmental impact of the use of those routes. The FSEIS lacks important information about when shipments will occur, what routes they will use to traverse the nation, and the impacts associated with the use of such routes. Since the FSEIS does not identify the affected environment for the proposed action, the FSEIS is insufficient and additional information will be required. Accordingly, DOE has illegally segmented the environmental analysis required under NEPA for Yucca Mountain. Therefore, the NRC cannot adopt the FSEIS as a portion of the License Application.

(2) Other

NEV-NEPA-17 - NRC STAFF'S NEPA REVIEW

1. A statement of the contention itself

Legal issue: NRC Staff's adoption determination violates NEPA, and therefore cannot support NRC's proposed action, because NRC Staff stated explicitly that it would not necessarily have arrived at the same NEPA conclusions on matters of fact or policy. This deficiency is significant, and if it were to be addressed in a satisfactory manner, the adoption decision could be materially different. As a result, the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

The provision in Section 114(f)(4) of the NWPA requiring that NRC adopt DOE's environmental impact statements to the extent practical, considered with 10 C.F.R. § 63.31(c), CEQ regulations, and case law under NEPA, does not allow NRC to adopt DOE's EISs, and therefore use them to satisfy its own NEPA duties, without stating whether it fully agrees with them. 10 C.F.R. § 63.31(c) is to the same effect. Note: this is styled as a NEPA contention, because it involves EISs, but it obviously includes consideration of closely related Section 114(f)(4) of the NWPA.

3. A demonstration that the contention is within the scope of the hearing

The Commission's regulations in 10 C.F.R. § 63.31(c), and section II, paragraph 1 of the Notice of Hearing, both provide that this issue is within the scope of the hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(c) provides that, before issuance of a construction authorization, NRC must find that such action is called for after weighing the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives. This

contention challenges compliance with NEPA and this provision and therefore raises a material issue.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

This contention raises a purely legal question, and supporting facts and opinions are not necessary beyond those discussed below. The deficiency is clearly significant from a legal perspective, and if it were to be addressed in a satisfactory manner by a more complete NRC Staff review, the adoption decision could be materially different.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

In its adoption determination, dated September 5, 2008 (U.S. Nuclear Regulatory Commission Staff's Adoption Determination Report for the U.S. Department of Energy's Environmental Impact Statements for the Proposed Geologic Repository at Yucca Mountain (09/05/2008), LSN# NRC000029699), the NRC Staff states (at ES-1) that its review:

> is neither a duplication of DOE's efforts nor a detailed review of all technical aspects of the analyses contained in the EISs. Further, an NRC staff determination of adoption of these EISs does not necessarily mean that NRC independently would have arrived at the same conclusions as DOE on matters of fact or policy.

See also LSN# NRC000029699 at 5-1. This contention challenges NRC's compliance with NEPA, CEQ regulations, and 10 C.F.R. § 63.31(c) in light of these statements. Supporting reasons are that the provision in Section 114(f)(4) of the NWPA requiring that NRC adopt DOE's environmental impact statements to the extent practical, considered with 10 C.F.R. § 63.31(c), CEQ regulations, and case-law under NEPA, neither excuses the NRC from fully analyzing DOE's statements, nor allows the NRC to rely on DOE environmental impact statements without stating whether it fully agrees with then.

NEV-NEPA-18 - OVERLAP BETWEEN NEPA AND AEA

1. A statement of the contention itself

Certain of Nevada's safety contentions challenging aspects of DOE's TSPA-LA are applicable to DOE's 2008 FSEIS and to NRC Staff's September 5, 2008 adoption decision (U.S. Nuclear Regulatory Commission Staff's Adoption Determination Report for the U.S. Department of Energy's Environmental Impact Statements for the Proposed Geologic Repository at Yucca Mountain (09/05/2008), LSN# NRC000029699). *See* Attachment 3, Affidavit of Michael C. Thorne, Attachment C. These contentions are significant, individually but especially cumulatively, and if they were to be addressed in a satisfactory manner, the disclosure of overall radiological impacts would be materially different. As a result, the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

Nevada has filed numerous contentions challenging aspects of DOE's TSPA-LA, and because DOE relies on essentially the same TSPA for estimating the radiological impacts from disposal at Yucca Mountain in its 2008 FSEIS, it follows that these contentions are applicable to DOE's FSEIS and to NRC Staff's September 5, 2008 adoption decision as well.

3. A demonstration that the contention is within the scope of the hearing

The Commission's regulations in 10 C.F.R. §§ 63.31(c) and 51.109(a)(2) and section II, paragraph 1 of the Notice of Hearing provide that these issues are within the scope of the hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(c) provides that, before issuance of a construction authorization, NRC must find that such action is called for after weighing the environmental, economic, technical,

and other benefits against environmental costs, and considers available alternatives. 10 C.F.R. § 51.109(a)(2) allows for challenges to NRC Staff's adoption decision. This contention falls within the scope of these regulations.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Nevada has filed numerous safety contentions (listed above) challenging aspects of DOE's TSPA-LA. From the FSEIS, specifically at Section 5.1a at 5-11; Section 5, Figure 5-1 at 5-5, and Appendix F at F-1 and F-3, it is clear that the model used in the FSEIS to evaluate potential post-closure impacts to human health from releases of radioactive materials is the so-called TSPA-SEIS, developed by Sandia in 2007, and that this model is nearly identical to the TSPA-LA. It follows that most of Nevada's safety TSPA-LA contentions are applicable to DOE's FSEIS and to NRC Staff's September 5, 2008 adoption decision as well. (U.S. Nuclear Regulatory Commission Staff's Adoption Determination Report for the U.S. Department of Energy's Environmental Impact Statements for the Proposed Geologic Repository at Yucca Mountain (09/05/2008), LSN# NRC000029699.)

The supporting facts and opinions are provided in Nevada's TSPA safety contentions listed above. It is clear from these contentions that they are significant, individually but especially cumulatively, and if they were to be addressed in a satisfactory manner, the disclosure of overall radiological impacts would be materially different. As a result, the FEIS and FSEIS cannot be adopted by the NRC.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

In its adoption determination the NRC Staff states (at 1-3, 3-15, and 5-1) that it adopts DOE's 2008 FSEIS, with specified and limited exceptions not pertaining to the adequacy of

DOE's TSPA in its FSEIS. This contention challenges NRC Staff's adoption decision and DOE's FSEIS as well.

NEV-NEPA-19 - PEAK DOSE IDENTIFICATION

1. A statement of the contention itself

DOE's 2008 FSEIS and 2002 FEIS are inadequate because neither calculates or discloses the reasonably foreseeable post-closure impacts to human health from releases of radioactive materials after one million years. This deficiency is significant, and if it were to be addressed in a satisfactory manner, the disclosure of overall radiological impacts would be materially different. As a result, the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

DOE's 2008 FSEIS and 2002 FEIS are inadequate because neither calculates or discloses the reasonably foreseeable post-closure impacts to human health from releases of radioactive materials after one million years. It is apparent from SAR Figure 2.4-10 at 2.4-424 that the RMEI expected dose curves (mean and 95th percentile) are still increasing at one million years, but there is no calculation or disclosure of any doses beyond this point.

3. A demonstration that the contention is within the scope of the hearing

The Commission's regulations in 10 C.F.R. §§ 51.109(a)(2) and 63.31(c), and section II, paragraph 1 of the Notice of Hearing, provide that this issue is within the scope of the hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31(c) provides that, before issuance of a construction authorization, NRC must find that such action is called for after weighing the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives. This contention challenges compliance with NEPA and this provision and therefore raises a material issue. 10 C.F.R. § 51.109(a)(2) also makes this a material issue.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

From Chapter 5 of the FSEIS at 5-2 it is clear both that estimates of potential radiological impacts to humans from disposal are truncated at one million years and that this truncation is arbitrarily based on EPA standards, promulgated pursuant to the EnPA of 1992, which allow such a truncation for the purpose of demonstrating compliance with the EPA dose standards. However, these standards do not purport to (and cannot) limit the scope of NRC's or DOE's NEPA obligations.

From Chapter 5 of the FEIS at 5-1 and 5-2, and Figure 5-5 at 5-30, it is clear that estimates of potential radiological impacts to humans from disposal are truncated at one million years. In the FEIS, at 5-26 and 5-29, this truncation was justified on the theory that radioactive decay after one million years would lead necessarily to doses lower than those calculated for the first one million years.

However, from SAR Figure 2.4-10 at 2.4-424 it is apparent that the RMEI expected dose curves (mean and 95th percentile) are still increasing at one million years, not decreasing. However, there is no calculation of any doses beyond this point. Therefore, environmental impacts (radiological impacts to humans, as measured by calculated dose) greater than those evaluated and disclosed in the FEIS and FSEIS are reasonably foreseeable. This deficiency is significant, and if it were to be addressed in a satisfactory manner, the disclosure of overall radiological impacts would be materially different. As a result, the FEIS and FSEIS cannot be adopted by the NRC.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's 2008 FSEIS and 2002 FEIS because neither calculates or discloses the reasonably foreseeable post-closure impacts to human health from releases of radioactive materials after one million years, and challenges NRC Staff's corresponding adoption decision, which takes no exception to this aspect of DOE's 2008 FSEIS and 2002 FEIS. The supporting reasons are given above in paragraph 5.

NEV-NEPA-20 - RADIONUCLIDE CONTAMINATION OF AQUIFER

1. A statement of the contention itself

The incomplete and inadequate 2002 FEIS and 2008 FSEIS analyses of cumulative impacts on groundwater quality due to contamination by radionuclides and other repository derived contaminants released to the volcanic/alluvial aquifer are significant deficiencies, and were they to be remedied, the disclosure of these impacts would be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis of the contention

The FEIS and FSEIS fail to describe the characteristics and behavior of the impacted volcanic-alluvial aquifer, the amount of radiological and non-radiological contaminants that can enter and accumulate in the aquifer through time, and the distribution and concentration of radiological and non-radiological contaminants in the aquifer through time.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a) and 63.24(c), whether NRC has complied with NRC regulations at 10 C.F.R. § 51.109(c)(2), as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

Consistent with Section 114(f)(4) of the Nuclear Waste Policy Act of 1982, as amended, [42 U.S.C. 10134], 10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. Consistent with 10 C.F.R. § 51.109(c)(2), 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

FEIS Subsection 5.4.1 at 5-23, Subsection 5.4.2 at 5-23, and Tables 5.6 at 5-24, 5.8 at 5-26, 5.10 at 5-28, and 5.12 at 5-29 considers radionuclide impacts (doses) at the RMEI location, 18 kilometers from the repository boundary, at 30 kilometers from the repository, and at a discharge location, Franklin Lake Playa, 60 kilometers from the repository. FEIS Subsection 5.6 at 5-32 and Table 5-14 at 5-33, and FSEIS Subsection 5.7 at 5-33 and Table 5-6 at 5-33 consider impacts of some waterborne chemically toxic materials, but only at the RMEI location and only for the period of 10,000 years after repository closure.

The radionuclide impacts calculated at 30 and 60 kilometers are based on a scaling factor which is applied to the impact (calculated dose) at the RMEI location. The scaling factor accounts only for expected dispersion of the contaminants in the plume in the alluvial aquifer (*see* FEIS Appendix I.4.5.2 at I-45 and 46). This approach does not provide an adequate analysis of the impacts of radiological contaminants in the aquifer beyond the RMEI location. Those radiological impacts are determined by local concentrations of radionuclides at any downstream location that is selected at some time in the future for groundwater abstraction. Because of the time-dependent nature of the source term and spatial heterogeneities in the aquifer, concentrations of radionuclides in a downstream location selected for ground water abstraction could be higher than those calculated for abstraction by the RMEI, as the rate of water extraction by the RMEI is prescribed by regulation.

The FEIS should include a description of the following phenomenon:

- the extent of the aquifer subject to contamination;
- an analysis of heterogeneities in the alluvial aquifer flow system that could affect radionuclide transport and concentration;
- an analysis of the potential for build-up of radionuclides in the aquifer due to retardation processes;
- an accounting of mass, concentration, and residence time of radionuclides in the affected aquifer throughout the regulatory period; and
- an assessment of potential long-term changes in the alluvial aquifer flow and transport system (including discharge) due to climate variation.

In sum, a 3D transient groundwater flow and transport model, over a spatial scale of tens of kilometers, is needed to support adequate analysis of the environmental impacts of radionuclide releases from the repository.

Neither FEIS Subsection 5.6 at 5-32 and 33 nor FSEIS Subsection 5.7 at 5-33 consider impacts of non-radiological contaminants in the aquifer beyond the RMEI location, at 18 kilometers from the repository boundary. In addition, neither of the referenced subsections considers impacts beyond 10,000 years after repository closure. The same types of analyses and descriptions called for above for radiological contaminants should be applied to non-radiological contaminants due to releases to the volcanic-alluvial aquifer from the repository.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

The impacted aquifer is the sole constant source of water for humans and the environment affected by releases from the repository. FSEIS Figure 5-3 at 5-24, shows the generalized regional groundwater flow system that is potentially impacted by radionuclide and non-radiological releases from a Yucca Mountain repository, but FEIS Subsection 5.4 at 5-22 through 5-31 and FSEIS Subsection 5.4 at 5-23 fail to adequately analyze the consequence of these contaminant releases to the volcanic-alluvial aquifer beyond the location of the RMEI at the boundary of the controlled area, 18 kilometers from the repository.

SAR General Information Subsection 5.2.2, and its subsections, at 5-40 through 5-59, provide some information on the nature of the regional flow system beyond the boundary of the controlled area, yet this information does not appear in either the FEIS of the FSEIS. Without this and additional information and analyses discussed above, the analysis of impacts of releases of radiological and non-radiological contaminants to the volcanic-alluvial aquifer beyond the boundary of the controlled area is incomplete and the FEIS does not meet the requirements of 10 C.F.R. §§ 51.67(a), 63.21(a), and 63.24(c).

NEV-NEPA-21 - CONTAMINATED AQUIFER DISCHARGES

1. A statement of the contention itself

The incomplete and inadequate 2002 FEIS and 2008 FSEIS analyses of the cumulative impacts of land surface discharge of groundwater contaminated with radionuclides and other repository derived contaminants are significant deficiencies, and were they to be remedied, the disclosure of these impacts would be materially different, thus the FEIS and FSEIS cannot be adopted by the NRC.

2. A brief summary of the basis of the contention

The FEIS and FSEIS fail to analyze the impacts of land surface discharge, at Franklin Lake Playa and from springs near Furnace Creek, of groundwater contaminated with radionuclides and other repository derived contaminants that can be concentrated by evaporation of water, plant uptake, mineral precipitation and other natural process, and subsequently redistributed in the environment.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a) and 63.24(c), whether NRC has complied with NRC regulations at 10 C.F.R. § 51.109(c)(2), as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

Consistent with Section 114(f)(4) of the Nuclear Waste Policy Act of 1982, as amended, [42 U.S.C. 10134], 10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. Consistent with 10 C.F.R. § 51.109(c)(2), 10 C.F.R. §

63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

FEIS Subsection 5.4 at 5-22 through 5-31, and Tables 5-6 at 5-24, 5-10 at 5-28, and 5-12 at 5-29, provide calculated ground water radionuclide dose levels at the Franklin Lake Playa discharge location, 60 kilometers (37 miles) from the repository boundary. These results, scaled for distance and radionuclide dispersion, are based on the calculated radionuclide dose at the location of the RMEI, 18 kilometers (11 miles) from the repository boundary. There is no consideration given to the chemical, physical, hydrologic and ecological processes that function at Franklin Lake Playa. Together, these processes can result in concentration of radionuclides in water, mineral precipitates, soils, and plants, and make some portion of the concentrated radionuclides available for redistribution in the environment by surface water flow and wind. These concentration and redistribution processes have the potential to result in higher radiological impacts to individuals accessing the contaminated areas than those arising to the RMEI, as the water use and habits of the latter are strongly constrained by regulation.

FEIS Subsection 3.1.4.2.1 at 3-40 through 3-50, and FSEIS Subsection 5.4 at 5-23 discuss how springs, near Furnace Creek in Death Valley, may discharge some water that could be contaminated by releases from the repository. Again, there is no consideration of the types of processes discussed above that function at the spring locations, resulting in concentration and redistribution of radionuclides in the environment.

FEIS Subsection 5.6 at 5-32 and 33, and FSEIS Subsection 5.7 at 5-33 consider the concentration in groundwater of nonradiological but chemically toxic materials that are included in repository releases. The analysis is only for the first 10,000 years after repository closure, and is done for groundwater concentrations at the location of the RMEI. The same concentration and redistribution factors that should have been considered and analyzed at the discharge locations for radionuclides should have been applied to the analysis of impacts of nonradiological contaminants from groundwater discharge to the land surface.

The approach taken in the FEIS and FSEIS does not provide an adequate analysis of the impacts of radiological contaminants in the aquifer beyond the RMEI location. Those radiological impacts are determined by local concentrations of radionuclides at any downstream location that is selected at some time in the future for groundwater abstraction. Because of the time-dependent nature of the source term and spatial heterogeneities in the aquifer, concentrations of radionuclides in a downstream location selected for ground water abstraction could be higher than those calculated for abstraction by the RMEI, as the rate of water extraction by the RMEI is prescribed by regulation.

The FEIS should include a description of the following phenomenon:

- the extent of the aquifer subject to contamination;
- an analysis of heterogeneities in the alluvial aquifer flow system that could affect radionuclide transport and concentration;
- an analysis of the potential for build-up of radionuclides in the aquifer due to retardation processes;
- an accounting of mass, concentration, and residence time of radionuclides in the affected aquifer throughout the regulatory period; and
- an assessment of potential long-term changes in the alluvial aquifer flow and transport system (including discharge) due to climate variation.

In sum, a 3D transient groundwater flow and transport model, over a spatial scale of tens of kilometers, is needed to support adequate analysis of the environmental impacts of radionuclide releases from the repository.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

FEIS Subsections 5.4 and 5.6, and FSEIS Subsections 5.4 and 5.7 fail to analyze the impacts of discharge of ground water contaminated with radionuclides and nonradiological materials from releases from the repository. For this reason the FEIS and FSEIS are incomplete and inadequate in their analysis of impacts of the repository. Because the discharge locations concentrate the radionuclides released to the environment at the land surface, these impacts are potentially the most severe among the impacts of the repository in the post-closure period, with the exception of potential extrusive igneous activity, yet they are not analyzed by DOE.

NEV-NEPA-22 - NO-ACTION ALTERNATIVE

1. A statement of the contention itself

The 2002 FEIS's No-Action Alternative is neither an available, appropriate, nor reasonable alternative for analysis and decision making in that neither of the two No-Action Alternative scenarios likely ever would be determined acceptable for implementation; however, the current practice of at-reactor (or off-site ISFSI), NRC licensed spent nuclear fuel storage can be extrapolated, for EIS comparative impact analysis purposes, for a reasonable and feasible period of time in the future. This deficiency is significant, and if it were to be addressed in a satisfactory manner, the disclosure of overall environmental impacts would be materially different. As a result, the FEIS cannot be adopted by the NRC.

2. A brief summary of the basis of the contention

FEIS at 7-1 identifies, as the two no-action alternatives, long-term storage of spent nuclear fuel and high-level radioactive waste at current sites with effective institutional control for at least 10,000 years, and long-term storage with no effective institutional control after about 100 years; however, neither alternative is likely, reasonable or feasible and instead both alternatives are remote and speculative.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a), 63.24(c), 63.31(c), 51.109(c)(2), the National Environmental Policy Act at 42 U.S.C. § 4332, as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts, 42 U.S.C. § 4332, requires DOE to study, develop, and describe appropriate alternatives to the recommended courses of action, and 40 C.F.R. §1502.14(a) requires DOE to rigorously explore and objectively evaluate all reasonable alternatives to the proposed action. Reasonable alternatives are those bounded by some notion of feasibility, and should not include remote or speculative alternatives. *See Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*, 435 U.S. 519, 551 (1978), and *Westlands Water District v. U.S. Department of Interior*, 376 F.3d 853, 868 (9th Cir. 2004). 10 C.F.R. § 63.31(c) requires consideration of available alternatives; and 10 C.F.R. § 51.67(a) requires consideration of alternatives, including license denial. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The FEIS at 7-1 considers two scenarios for the No-Action Alternative: (a) long-term storage of spent nuclear fuel and high-level radioactive waste at current sites with effective institutional control for at least 10,000 years; and (b) long-term storage with no effective institutional control after about 100 years. DOE's rationale for selecting these two scenarios is as follows: "Although the Department agrees that neither of these scenarios is likely, it selected them for analysis because they provide a basis for comparison to the impacts of the Proposed Action and because they reflect a range of the impacts that could occur." FEIS at 7-1.

Despite its stated rationale, DOE has selected two No-Action Alternative scenarios that never would become available, which is a clear violation of 10 C.F.R. § 63.31(c), the National Environmental Policy Act, 42 U.S.C. § 4332, and implementing CEQ regulations at 40 C.F.R. § 1502.14(a), which call for analysis of appropriate and reasonable alternatives. 40 C.F.R. § 1502.14(d) requires that the analysis of alternatives to the proposed action include the alternative of no action.

There is no regulatory or policy precedent for the No-Action Alternative scenarios adopted by DOE's FEIS. Scenario 1 would require an impossible commitment to at least 10,000 years of institutional controls, and consistent serial expenditures of funds for human activities, including construction and monitoring – a commitment that exceeds credibility. Scenario 2, for the first one hundred years, storage is not inconceivable, with proper oversight and financial commitment. Following the first 100 years of institutional controls, however, it is inconceivable that society would accept the willful decision to cease maintenance, and permit the eventual facility degradation that would result in uncontrolled massive release of radionuclides to the environment.

This deficiency is significant, and if it were to be addressed in a satisfactory manner, the disclosure of overall environmental impacts would be materially different. As a result, the FEIS cannot be adopted by the NRC.

A reasonable strategy for analysis of the No-Action Alternative could be the following: For the sole purpose of impact comparison in the EIS analysis of no-action, the pre-closure impacts of developing, operating and closing the repository, under the capacity scenarios described in the EIS, could be compared to the analyzed impacts of storing the waste, in equivalent amounts, at on-site or off-site facilities, for an equivalent period of time. This would represent a reasonable and feasible comparison. In general, analysis of this type of storage scenario does not greatly differ from the timeline for safe storage laid out in NRC's Waste Confidence generic determination, at 10 C.F.R. § 51.23(a), or its proposed revision, only in this case, the expected impacts actually would be analyzed, rather than generically determined to be not significant.

The post-closure repository impacts are analyzed in the FEIS and FSEIS. For purposes of the No-Action Alternative analysis, it could be stated that analysis beyond the scope described above would be unreasonable, remote, speculative, and infeasible to the extent that comparison between the impacts of the Proposed Action and a No-Action Alternative would be meaningless. If the No-Action Alternative were to become reality, this analysis strategy presumes that at some time within the period of time analyzed, an acceptable means of managing the long-term risks of high-level radioactive waste and spent nuclear fuel would have begun to be implemented.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges DOE's no action alternatives identified in the FEIS as unreasonable, remote and speculative, and outside the bounds of feasibility, and thus not in compliance with governing statutory and regulatory requirements and applicable case law. Accordingly, NRC should refrain from adopting either no action alternative presented by DOE.

NEV-NEPA-23 - AIRCRAFT CRASH SCENARIOS – AGING FACILITY

1. A statement of the contention itself

SEIS Appendix E, Section E.7, which states that DOE did not consider the Aging Facility to be vulnerable to a hypothetical sabotage scenario involving a large commercial jet aircraft crash due to the spacing and protective nature of the concrete overpacks, fails to accurately identify the number of overpacks damaged, fails to accurately assess the severity of the damage from such a crash, and fails to accurately analyze the amount of radioactive material that would be released from such a crash. These deficiencies are significant, and if they were to be addressed in a satisfactory manner, the disclosure of overall radiological impacts would be materially different, and thus the FEIS and SEIS cannot be adopted by the NRC.

2. A brief summary of the basis for the contention

Notwithstanding the spacing of the overpacks on the Aging Facility and the thickness of their concrete enclosures, reference documents from DOE and publicly available sources make clear that the speed and type of the aircraft that could impact the Aging Facility is materially different than that assumed by DOE in its analysis, and that if proper consideration is given to representative aircraft characteristics significant damage to the overpacks on the Aging Facility could occur and such damage would release greater amounts of radioactive material than analyzed by DOE.

3. A demonstration that the contention is within the scope of the hearing

The contention raises an issue whether DOE has complied with the NRC regulations at 10 C.F.R. §§ 51.67(a), 63.21(a) and 63.24(c), as well as case law involving environmental impact statements, which apply to Yucca Mountain, and falls within the scope of the hearing as specified in 10 C.F.R. §§ 51.109(a)(2) and 63.31(c) and section II, paragraph 1 of the Notice of Hearing.

4. <u>A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain</u>

10 C.F.R. §§ 51.67(a) and 63.21(a) require DOE to submit an environmental impact statement (EIS) with its LA. 10 C.F.R. § 63.24(c) requires DOE to supplement its EIS to take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts. An environmental impact statement must contain a reasonably thorough discussion of the significant probable environmental consequences and must discuss the environmental impacts of the proposed action – which requires DOE to take a hard look at the potential environmental consequences of the proposed action. *See Northwest Ecosystem Alliance v. Rey*, 380 F. Supp. 2d 1175, 1185 (W.D. Wash. 2006); and *Idaho Conservation League v. Mumma*, 956 F.2d 1508, 1519 (9th Cir. 1992). *See also Public Service Electric & Gas Co. (Hope Creek Generating Station)*, ALAB-518, 9 NRC 14 (1979); and *Florida Power & Light Co. (Turkey Point Units 3 & 4)*, LBP-81-14, 13 NRC 677 (1981). 10 C.F.R. § 63.31(c) provides that a construction authorization will not issue until the NRC weighs the environmental, economic, technical, and other benefits against environmental costs, and considers available alternatives contained in the EIS. This contention alleges non-compliance with these regulatory provisions and case-law requirements, and therefore raises a material issue within the scope of the licensing proceeding.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

SEIS Subsection 4.1.8.1 at 4-77 and 4-78 states that DOE analyzed a hypothetical sabotage scenario in which a large commercial jet aircraft crashes into and penetrates the repository facility with the largest inventory of radioactive materials vulnerable to damage from such an event, and references SEIS Appendix E, Section E.7 as containing the details of the analysis. SEIS Appendix E, Section E.7 at E-32 states that DOE did not consider the Aging Facility to be vulnerable to the aircraft crash scenario (even though it contains a large amount of commercial spent nuclear fuel) because (a) the overpacks located on the Aging Facility pads would be spaced 18 feet apart, such that an aircraft crash into the pad could not damage more than a few of the overpacks, referencing "Aging Facility General Arrangement Aging Pad 17R Plan" (11/20/2007), LSN# DEN001564784, solo page, and (b) the storage canisters would be enclosed in thick concrete that would provide protection from penetration by aircraft parts, referencing EIS Section 7.2.1.8 and EIS Appendix H, Section H.2.1.3. In addition, SEIS Appendix E, Section E.7 at E-32 states that DOE would design the TAD aging overpacks to withstand the impact from a jet fighter aircraft crash, referencing SEIS Subsection E.2.1.2.1.

DEN001564784 (solo page) illustrates that Aging Pad 17R has 8 subpads, with each subpad containing 144 vertical overpacks within an area that is 678 feet long by 54 feet wide. The 8 subpads are configured in a 4x2 array such that the two subpads lie "end-to-end" with a combined length (from the first vertical overpack on the first subpad to the last vertical overpack on the second subpad) of 1471 feet. The same drawing of Aging Pad 17R is presented as SAR Figure 1.2.7-4 at 1.2.7-25. SAR Subsection 1.2.7.1.3.2.1 at 1.2.7-6 states that the vertical overpacks are designed for placement on the aging pads without any seismic restraints or other tie-downs.

EIS Section 7.2.1.8 at 7-30 references an analysis performed in 1998 of an aircraft crash into an above-ground dry-storage facility at a US commercial nuclear power plant site, *see* "Accident Analysis for Continued Storage," Rev. 0 (10/27/1998), LSN# DN2002068868, and concludes that falling aircraft components produced by such an event would not penetrate the storage facility and that any subsequent fire would not result in facility failure. The accident analysis (DN2002068868 at 2 and 5) assumed the aircraft would be the Boeing 757 commercial jet or one of 3 military jets (F-15, F-16, or A-10), but acknowledged that the size of the aircraft has an influence on the probability of intersecting the storage facility during a crash. The analysis (*id*. at 2 and 4) also acknowledged that in addition to direct impacts, commercial aircraft can skid up to 1440 feet into structures. Further, the analysis (*id*. at 6) assumed the aircraft would impact a concrete storage module at 550 fps (~340 mph) but acknowledged that the aircraft impact velocity depends on the type of aircraft and the flight configuration at the time of impact. Further, the analysis (*id*. at 5-6) calculates a maximum penetration depth of 2.8 feet in concrete using a formula that varies by the square of the aircraft velocity at impact. EIS Section 7.2.1.8, at 7-30, also concludes that where aircraft velocities could be higher, there would be an increased potential that the intact storage facility could be subject to failure, resulting in a release of radiological materials.

SEIS Subsection E.2.1.2.1 at E-11 states that the aging overpack module is designed to withstand the largest of the most likely aircraft impact, which would be an F-15 fighter aircraft with an impact speed of 152 meters per second (500 feet per second), referencing "Transportation, Aging and Disposal Canister System Performance Specification" (06/11/2007), LSN# DN2002408350 at 25. The Performance Specification (DN2002408350 at 25) provides that the TAD canister must withstand the impact of an F-15 military aircraft traveling at a speed of 500 fps.

DOE reference document "Identification of Aircraft Hazards" (7/3/2007), LSN# DN2002406192 at B-2 through B-7, though not referenced in any of the above-cited SEIS or EIS sections, provides additional information regarding the flight characteristics of the military aircraft that regularly operate in airspace above and nearby the Yucca Mountain site. Specifically, the F-15 jet flies at speeds in excess of 1100 mph, the F-16 jet flies at speeds in excess of 980 mph, the A-10 jet flies at speeds in excess of 500 mph, and the B-52 bomber flies at speeds of approximately 480 mph. Publicly available information on the B-52 bomber reveals that the aircraft has a wingspan of 185 feet which house 8 engines. *See* "U.S. Air Force Fact Sheet, B-52 Stratofortress" (10/2005), LSN# NEV000005489 at 1-2. The Boeing 757 aircraft has a wingspan of 124 feet and a cruise speed in excess of 525 mph. *See* "Boeing 757-300 Technical Characteristics" (2008), LSN# NEV000005486, solo page.

Based upon the above information, if either the Boeing 757 commercial aircraft or the B-52 military bomber were to crash and skid on the aging pad, over 500 overpacks would be damaged (not the "more than a few" referred to in SEIS Appendix E.7, Subsection E.7 at E-32). In addition, if the B-52, Boeing 757, or any of the three military jets were to crash, their speeds would exceed by 41 to 224 percent the speeds assumed in the 1998 analysis. Since the EIS and the referenced 1998 accident analysis (DN2002068868) both acknowledge that the maximum penetration depth of concrete resulting from an aircraft crash varies by the square of the velocity at impact, higher aircraft velocities would increased the potential for a failure of the overpack and release of radiological materials, particularly with regard to the B-52 bomber which would be carrying 4 to 8 times as many engines as assumed for the other aircraft.

Since the SEIS fails to provide a reasonably thorough discussion of the type of aircraft that could impact the Aging Facility and their associated flight characteristics, and fails to provide a reasonably thorough assessment of the environmental consequences and impacts that would occur as a result of such impacts, DOE has failed to provide the requisite hard look with regard to aircraft crash scenarios as required in an environmental impact statement. Therefore, DOE has failed to comply with the requirements of 10 C.F.R. §§ 51.67(a), 63.21(a), and 63.24(c) to submit an environmental impact statement that takes into account the environmental impacts associated with the proposed action, and thus the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(c).

These deficiencies are significant, and if they were to be addressed in a satisfactory manner, the disclosure of overall radiological impacts would be materially different. As a result, the FEIS and SEIS cannot be adopted by the NRC.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges SEIS Appendix E, Section E.7, which in turn relies on DOE reference document DEN001564784, and EIS Section 7.2.1.8, which states that DOE did not consider the Aging Facility to be vulnerable to the aircraft crash scenario because the overpacks located on the Aging Facility pads would be spaced 18 feet apart and because the storage canisters would be enclosed in thick concrete designed to withstand the impact from a crash of an F-15 military fighter jet. As indicated above, there is sufficient information to believe that DOE's discussion in SEIS Appendix E, Section E.7 is materially incomplete and inaccurate because it fails to provide a reasonably thorough discussion of the type of aircraft that could impact the Aging Facility and their associated flight characteristics, fails to provide a reasonably thorough assessment of the environmental consequences and impacts that would occur as a result of such impacts, and thus fails to provide the requisite hard look with regard to aircraft crash scenarios as required in an environmental impact statement. As a result, SEIS Appendix E, Section E.7 does not comply with the requirements of 10 C.F.R. §§ 51.67(a), 63.21(a), and 63.24(c) to submit an environmental impact statement that takes into account the environmental impacts associated with the proposed action.. As a result, the Yucca Mountain repository cannot be licensed pursuant to 10 C.F.R. § 63.31(c).

C. Miscellaneous Contentions

NEV-MISC-01 - EROSION AND GEOLOGIC DISPOSAL

1. A statement of the contention itself

Legal issue: The construction authorization cannot be granted because, as contention NEV-SAFETY-41 establishes, Yucca Mountain will erode to the level of the repository drifts beginning around 500,000 years after waste emplacement, thereby exposing the waste packages to the atmosphere, with the result that for the period after about 500,000 years and continuing throughout the period of geologic stability the facility will no longer constitute a "repository" but would, at best, constitute a retrievable storage facility, in violation of sections 2(18),114(d), 141(g) and 302(d) of the NWPA, section 801(a) of the EnPA, and Public Law No. 107-200 (42 U.S.C. § 10135 note).

2. A brief summary of the basis for the contention

Sections 2(18),114(d), and 302(d) of the NWPA, section 801(a) of the Energy Policy Act of 1992, and Public Law No. 107-200 (42 U.S.C. § 10135 note) provide only for construction and licensing of a "repository" at Yucca Mountain. A repository requires geologic disposal but, as contention NEV-SAFETY-41 establishes, Yucca Mountain will erode to the level of the repository drifts about 500,000 years after waste emplacement, thereby exposing the HLW waste packages to the atmosphere. Once this happens, the Yucca Mountain facility will no longer be a repository but will be, at best, an above-ground storage facility prohibited by section 141(g) of the NWPA.

Note: while several different statutes are cited, they are so closely related for the purpose of this issue that separate contentions addressed to separate statutes would be unreasonably duplicative.

3. A demonstration that the contention is within the scope of the hearing

10 C.F.R. § 63.31 only authorizes the NRC to issue a construction authorization for a "geologic repository operations area" which, in accordance with 10 C.F.R. § 63.2, must include permanent disposal in excavated geologic media. In accordance with the referenced contention, Yucca Mountain will not provide for disposal in excavated geologic media during the entire period while the HLW remains dangerous. Accordingly, this issue must be addressed and resolved in order for the NRC to make any favorable findings pursuant to 10 C.F.R. § 63.31 and the issue is within the scope of the hearing as provided in section II, paragraph 1 of the notice of hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This issue must be addressed and resolved in order for the NRC to make any favorable findings pursuant to 10 C.F.R. § 63.31. The issue is therefore material.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Sections 2(18),114(d), and 302(d) of the NWPA, section 801(a) of the EnPA, and Public Law No. 107-200 (42 U.S.C. § 10135 note) provide only for construction and licensing of a "repository" at Yucca Mountain. A repository requires geologic disposal but, as contention NEV-SAFETY-41 establishes, Yucca Mountain will erode to the level of the repository drifts as soon as 500,000 years after waste emplacement, thereby exposing the waste packages to the atmosphere. Once this happens, there will no longer be any geologic disposal at Yucca Mountain and the facility will, at best, constitute an above-ground storage facility prohibited by section 141(g) of the NWPA.

Moreover, 10 C.F.R. § 63.31 only authorizes the NRC to issue a construction authorization for a "geologic repository operations area" which, in accordance with 10 C.F.R. § 63.2, must include permanent disposal in excavated geologic media. In accordance with the referenced contention, Yucca Mountain will not provide for disposal in excavated geologic media. Accordingly, this issue must be addressed and resolved in order for the NRC to make any favorable findings pursuant to 10 C.F.R. § 63.31.

Supporting facts and technical opinions are in NEV-SAFETY-41.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the fundamental factual premise for DOE's LA, that Yucca Mountain may be licensed as a geologic repository in accordance with the statutes cited above. In particular, this contention challenges DOE assertion of NRC jurisdiction and characterization of Yucca Mountain as a repository in the General Information portion of the LA, section 1.3 at 1-20 to 1-21. The reasons are given above.

NEV-MISC-02 - ALTERNATE WASTE STORAGE PLANS

1. A statement of the contention itself

Legal issue: The LA cannot be granted because its discussion of alternate storage plans for spent fuel following retrieval violates the NWPA.

2. A brief summary of the basis for the contention

Subsection 1.11 of the SAR at 1.11-1 through 1.11-16 describes DOE proposed plans for alternate storage of radioactive waste should retrieval be necessary. It includes a conceptual layout for facilities for on-site storage, but no information about storage outside of Nevada. *See* SAR Subsection 1.11.2 at 1.11-11. Without concrete plans for alternate storage outside of Nevada, storage of retrieved spent fuel in Nevada becomes indefinitely long-term. However, a facility for indefinitely long-term storage of spent fuel in Nevada, unrelated to efficient disposal of spent fuel in a safe and viable repository, would violate Section 141(g) of the NWPA, which prohibits locating any long-term spent fuel storage facility in Nevada.

3. A demonstration that the contention is within the scope of the hearing

This issue must be addressed and resolved because it alleges that DOE's application violates applicable law. Moreover, this issue must be resolved in order for the NRC to find that the application complies with 10 C.F.R. § 63.21(c)(7), as required by 10 C.F.R. § 63.31(a)(3), because a plan for alternate storage that violates the law cannot be implemented. Further, the issue is within the scope of the hearing as provided in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This issue must be addressed and resolved because it alleges that DOE's application violates applicable law. Moreover, this issue must be resolved in order for the NRC to find that the application complies with 10 C.F.R. § 63.21(c)(7), as required by 10 C.F.R. § 63.31(a)(3), because a plan for alternate storage that violates the law cannot be implemented. The issue is therefore material.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Subsection 1.11 of the SAR at 1.11-1 through 1.11-16, which describes DOE proposed plan for alternate storage of radioactive waste should retrieval be necessary, provides no information about storage outside of Nevada. Without concrete plans for alternate storage outside of Nevada, storage of retrieved spent fuel in Nevada becomes indefinitely long-term. However, a facility for indefinitely long-term storage of spent fuel in Nevada, unrelated to efficient disposal of spent fuel in a safe and viable repository, would violate Section 141(g) of the NWPA, which prohibits locating any long-term spent fuel storage facility in Nevada.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

This contention challenges the adequacy of SAR Subsection 1.11 at 1.11-1 through 1.11-16, especially SAR Subsection 1.11.2 at 1.11-11. Supporting reasons are given in supporting facts and opinions above.

NEV-MISC-03 - LA REFERENCES

1. A statement of the contention itself

Error of Omission: The LA SAR is insufficient on its face because it cannot be determined whether its safety conclusions are correct without also considering about 196 references listed therein, but as provided in LA General Information Subsection 1.4.1 at 1-21, DOE refuses to incorporate these references into the LA.

2. A brief summary of the basis for the contention

The LA SAR is insufficient on its face because it cannot be determined whether its safety conclusions are correct without also considering about 196 references listed therein but, as provided in LA General Information Subsection 1.4.1, at 1-21, DOE refuses to incorporate these references into the LA.

3. A demonstration that the contention is within the scope of the hearing

The contention questions compliance with Commission's regulations and is within the scope of the hearing pursuant to section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

10 C.F.R. § 63.31 provides that safety findings are to be made "on review and consideration of an application," and 10 C.F.R. § 63.24 reinforces the concept that the LA is the basis for the NRC's safety review by requiring that the application be as complete as possible in light of reasonable available information. This contention raises the issue whether the safety findings required by 10 C.F.R. § 63.31(a) can be made on the basis of the information in the SAR itself and the closely related issue whether DOE has complied with 10 C.F.R. § 63.24.

5. <u>A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials</u>

The SAR has 196 "general references," listed in numerous subsections, all of which are entitled "General References." *See, e.g.*, SAR Subsections 1.1.10 at 1.1-164 through 1.1-181 and 1.2.1.6 at 1.2.1-21. Most of these references are technical support documents generated by DOE and its contractors for the purpose of characterizing the Yucca Mountain Site and preparing the LA. For example, the post-closure TSPA is described in a summary, largely narrative fashion in SAR Chapter 2, and more specifically in Subsection 2.4 at 2.4-1 through 2.4-595, but the actual TSPA Model that supports these SAR provisions is in a reference entitled "SNL-2008a, Total Systems Performance Assessment Model/Analysis for the License Application," which is listed in Subsection 2.4.5, "General References," at 2.4-348. In accordance with LA General Information Subsection 1.4.1, at 1-21, this referenced document is not actually any part of the SAR.

It is clear from Nevada's contentions addressed to the SAR, specifically paragraphs 5 of those contentions, that Nevada's experts usually found it impossible to review the safety conclusions in the cited subsections of the SAR, especially those in Chapter 2, without considering scientific facts and analyses in the referenced documents, and sometimes also scientific facts and analyses in documents referenced in the references. Therefore, these contentions support the propositions that (1) the subsections of the SAR addressed by these Nevada's contentions are incomplete and inadequate without incorporation of the references pursuant to 10 C.F.R. § 63.23, (2) without such incorporation, no safety findings based solely on the SAR can be made, and (3) the LA is deficient on its face, at least with respect to these subsections. This contention could be narrowed to challenge only those subsections of the SAR addressed by Nevada's safety contention, but this would lose sight of the broader problem, explained below.

Nevada's safety contentions addressed to the SAR do not include an exhaustive compendium of all references that must be included in the SAR. Doing so would require an in-depth, expert review of every subsection of the SAR, which is beyond the reasonable capability of any intervenor and is not necessary to identify a wide range of matters of genuine dispute. However, Nevada's contentions are sufficiently numerous and detailed to support the reasonable inference that the completeness deficiencies found in the cited SAR subsections likely permeate the entire SAR.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

This contention challenges the sufficiency of the SAR and, more specifically, DOE's refusal in LA General Information Subsection 1.4.1, at 1-21, to incorporate general references into the LA. The reasons are given above in paragraph 5.

NEV-MISC-04 - AGING FACILITY ROLE UNDER NWPA

1. A statement of the contention itself

DOE's plan to have up to 21,000 metric tons of heavy metal sitting on "aging pads" for decades violates the Nuclear Waste Policy Act, as amended, by making Nevada the site of both a repository and a retrievable storage facility.

2. A brief summary of the basis for the contention

Whether denominated for "cooling" or otherwise, the "aging pad" on which DOE plans to store potentially tens of thousands of metric tons of heavy metal is unlawful because it violates a prohibition in the Nuclear Waste Policy Act against placing retrievable nuclear waste storage in the same state as the site being considered for the repository.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with the express statutory and regulatory requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the Notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This contention addresses whether DOE's license application violates Sections 111(a)(5) and 141(g) of the Nuclear Waste Policy Act, as amended, 42 U.S.C. §10131(a)(5) and §10161(g), and the Commission's regulations promulgated thereunder, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention, along with appropriate citations to supporting scientific or factual materials

Section 111(a)(5) of the Nuclear Waste Policy Act, as amended, provides that "the generators and owners of high-level radioactive waste and spent fuel have the primary responsibility to provide for, and responsibility to pay for the costs of, the interim storage of such waste and spent fuel until such waste and spent fuel is accepted by the Secretary of Energy in accordance with the provisions of this Act [42 U.S.C. §10101, *et seq*.]." 42 U.S.C. §10131(a)(5). Section 141(g) of the Act, 42 U.S.C. §10161(g), proscribes in relevant part that "[n]o monitored retrievable storage facility developed pursuant to this section may be constructed in any State in which there is a located any site approved for site characterization under section 10132 of this title," and that "[s]uch restriction shall continue to apply to any site selected for construction as a repository."

Title 10 C.F.R. § 72.3 defines "Monitored Retrievable Storage Installation or MRS" as "a complex designed, constructed, and operated by DOE for the receipt, transfer, handling, packaging, possession, safeguarding, and storage of spent nuclear fuel aged for at least one year, solidified high-level radioactive waste resulting from civilian nuclear activities, and solid reactor-related GTCC waste, pending shipment to a HLW repository or other disposal." That same section defines "Independent spent fuel storage installation or ISFSI" as "a complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related GTCC waste, and other radioactive materials associated with spent fuel and reactor-related GTCC waste storage. An ISFSI which is located on the site of another facility licensed under this part or a facility licensed under part 50 of this chapter and which shares common utilities and services with that facility or is physically connected with that other facility may still be considered independent."

The license application, however, contemplates an aging facility that is both a "monitored retrievable storage installation and an "independent spent fuel storage installation." DOE claims that the pertinent functions of the aging facility are to provide "capability to place commercial

SNF in a location where it can be aged to appropriate thermal power levels, providing passive heat removal to preclude exceeding waste form temperature limits" and; to provide "capability to uncouple receipt of commercial SNF from emplacement of commercial SNF by creating a location to temporarily place commercial SNF until the waste emplacement process can accommodate it." Section 1.2.7.1.1 at 1.2.7-4.

The Nuclear Waste Policy Act and the Commission's regulations do not permit DOE to establish a facility for this purpose in the State of Nevada. In addition, because the aging pad is both a monitored retrievable storage installation and an independent spent fuel storage installation, it would need to meet requirements under Part 72 of the Commission's regulations, which DOE does not purport to meet.

6. <u>There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted</u>

Subsections 1.1.2.1 at 1.1-23, and 1.2.7 and its various subsections of the SAR, and similar and related subsections, describe a plan to locate on the surface of the Geologic Repository Operations Area ("GROA") "aging facilities" that violate the law and these regulations. The SAR describes the Aging Facility among the Major Surface Facility Structures and Systems (section 1.2.1.2 at 1.2.1-7) as a facility that can accommodate up to 21,000 MTHM with a total of 2,500 spaces for aging overpacks (each containing 1 TAD), and 100 spaces for horizontal modules (each containing one DPC). Section 1.2.7 more fully describes the Aging Facility.

The Aging Facility as conceived in the SAR is interim storage of commercial SNF – interim between removal from the reactor and emplacement in the repository. This violates the law.

NEV-MISC-05 - ROLE OF AGING FACILITY

1. A statement of the contention itself

SAR Subsections 1.1.2.1 and 1.2.7, and various similar and related subsections, which describe DOE's plan to construct and operate an Aging Facility at the GROA is neither necessary for nor integral to the safe operation of the repository, and cannot be justified under the NWPA.

2. A brief summary of the basis for the contention

Even if the Nuclear Waste Policy Act, 42 U.S.C. § 10101, *et. seq.,* permitted DOE to construct an aging facility on the Yucca Mountain repository site for the ostensible purpose of providing a location for cooling transport, aging and disposal canisters (TADs) (which it does not), DOE's "aging pad" would still violate the Act because the cooling that DOE purports to obtain is not necessary and the 21,000 metric tons of heavy metal (MTHM) capacity of the aging pad has no demonstrated basis.

3. A demonstration that the contention is within the scope of the hearing

This contention raises an issue of whether DOE has complied with the express statutory and regulatory requirements applicable to Yucca Mountain, and falls within the scope of the hearing as specified in section II, paragraph 1 of the notice of Hearing.

4. A demonstration that the contention is material to the findings NRC must make to license Yucca Mountain

This contention addresses whether DOE's license application violates Sections 111(a)(5) and 141(g) of the Nuclear Waste Policy Act, as amended, 42 U.S.C. §§ 10131(a)(5) and 10161(g), and the Commission's regulations promulgated thereunder, and therefore raises a material issue within the scope of the licensing proceeding.

5. A concise statement of the facts or expert opinions supporting the contention along with appropriate citations to supporting scientific or factual materials

Section 111(a)(5) of the Nuclear Waste Policy Act, as amended, 42 U.S.C. § 10131(a)(5) provides that "the generators and owners of high-level radioactive waste and spent nuclear fuel have the primary responsibility to provide for, and responsibility to pay for the costs of, the interim storage of such waste and spent fuel until such waste and spent fuel is accepted by the Secretary of Energy in accordance with the provisions of this Act [42 U.S.C. § 10101, *et. seq.*]." Section 141(g) of the Act, 42 U.S.C. § 10161(g), proscribes in relevant part that "[n]o monitored retrievable storage facility developed pursuant to this section may be constructed in any State in which there is a located any site approved for site characterization under section 10132 of this title," and that "[s]uch restriction shall continue to apply to any site selected for construction as a repository."

10 C.F.R. § 72.3 defines "Monitored Retrievable Storage Installation or MRS" as "a complex designed, constructed, and operated by DOE for the receipt, transfer, handling, packaging, possession, safeguarding, and storage of spent nuclear fuel aged for at least one year, solidified high-level radioactive waste resulting from civilian nuclear activities, and solid reactor-related GTCC waste, pending shipment to a HLW repository or other disposal." That same section defines "Independent spent fuel storage installation or ISFSI" as "a complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related GTCC waste, and other radioactive materials associated with spent fuel and reactor-related GTCC waste storage. An ISFSI which is located on the site of another facility licensed under this part or a facility licensed under part 50 of this chapter and which shares common utilities and services with that facility or is physically connected with that other facility may still be considered independent."

The License Application, however, contemplates an aging facility that is both a "monitored retrievable storage installation and an "independent spent fuel storage installation." SAR Subsection 1.2.1.2 at 1.2.1-7 describes the Aging Facility among the Major Surface Facility Structures and Systems as a facility that can accommodate up to 21,000 MTHM with a total of 2,500 spaces for aging overpacks (each containing 1 TAD), and 100 spaces for horizontal modules (each containing one DPC). SAR Subsection 1.2.7 more fully describes the Aging Facility. DOE claims that the pertinent functions of the Aging Facility are to provide "capability to place commercial SNF in a location where it can be aged to appropriate thermal power levels, providing passive heat removal to preclude exceeding waste form temperature limits" and; to provide "capability to uncouple receipt of commercial SNF from emplacement of commercial SNF by creating a location to temporarily place commercial SNF until the waste emplacement process can accommodate it." SAR Subsection 1.2.7.1.1 at 1.2.7-4.

Even if the Nuclear Waste Policy Act and the Commission's regulations, permitted the construction of an on-site aging facility that genuinely served these purposes (which they do not), DOE's explanation for this aging pad is pretextual. First, an alternative thermal management evaluation, based on the mountain's thermal conductivity rather than a predicted thermal characteristic of the waste stream, suggests that DOE does not actually need the cooling it claims to require. *See* "Thermal-Response Evaluation of Yucca Mountain During the Preclosure and Post-Closure Phases" (Nuclear Waste Technical Review Board (NWTRB) 07/2008), LSN# NEV000005151. This NWTRB study concludes: "Surface aging of the hotter Commercial Spent Nuclear Fuel (CSNF), as opposed to subsurface aging, has limited benefit on the postclosure thermal response. DOE should reevaluate the need to surface-age the CSNF at the repository." *Id.* at 27.

Second, even if cooling were required, there is no reason, nor apparent explanation in the license application, for why the cooling must take place at the repository instead of the generation sites as Congress contemplated.

Third, the capacity of the aging pad vastly exceeds any that could be necessary for cooling, in any event. It can be calculated that 43 percent of TADs arriving at the GROA will spend some period of time stored in the Aging Facility. *See* "Engineering Study: Total System Model Scoping Analysis of Aging for a 25 kW TAD Waste Stream" (Bechtel SAIC, 05/2007), LSN# DN2002411835, Table 2 at 6. However, the 21,000 MTHM capacity of the Aging Facility has not been justified in the SAR as being needed for thermal blending purposes. DOE, itself, suggests that thermal blending using a 2 to 4-year inventory base would require less than 11,000 MTHM, but it has not provided any basis for this (or any other) inventory base. *See* "Thermal Management Strategy for the LA" (Bechtel SAIC, 03/22/2007), LSN# DN2002499641 at 14 and 17.

The aging pad is thus, not integral to the operation of the repository. The cooling it is supposed to provide is not necessary and the 21,000 MTHM capacity is far beyond anything necessary to provide lag storage for waste handling, in any event. The real reason for having an aging pad, is instead, to provide a means of providing what the law prohibits: interim storage away from the generation sites, for which there is no statutory or regulatory authorization. *See* Letter from R. Loux, Executive Director, Agency for Nuclear Projects, State of Nevada to D. Klein, Chairman, U.S. Nuclear Regulatory Commission, "Spent Fuel 'Aging Facility' at Yucca Mountain" (08/18/2006), LSN# DN2002313326.

The Nuclear Waste Policy Act and the Commission's regulations do not permit DOE to establish the Aging Facility at the GROA in the State of Nevada. In addition, because the aging pad is both a monitored retrievable storage installation and an independent spent fuel storage installation, it would need to meet requirements under Part 72 of the Commission's regulations, which DOE does not purport to meet.

6. There must be sufficient information to show that there is a genuine dispute with DOE, along with specific references to the portions of the LA being controverted

SAR Subsections 1.1.2.1 and 1.2.7, and its various subsections and similar and related subsections, describe a plan to locate on the surface of the GROA "aging facilities" that violate the Nuclear Waste Policy Act, as amended, and implementing NRC regulations. The Aging Facility as conceived in the SAR is interim storage of commercial SNF – interim between removal from the reactor and emplacement in the repository. This violates the law.

IV. CONCLUSION AND PRAYER FOR RELIEF

Based on the foregoing, the Department of Energy's License Application should be denied.

Respectfully submitted,

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Dated: December 19, 2008

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
	)	
(High Level Waste Repository)	)	November 24, 2008

CERTIFICATE OF SERVICE

I hereby certify that the foregoing State of Nevada's Petition to Intervene as a Full Party has been served upon the following persons either by Electronic Information Exchange or electronic mail (denoted by an asterisk (*)).

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(signed electronically)
Susan Montesi

Attachment 1

Affidavit of Robert R. Loux

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF ROBERT R. LOUX (ON STANDING)

I, Robert R. Loux, do hereby swear that the following matters are true and correct based on my personal knowledge:

1. I am the Executive Director of the Nevada Agency for Nuclear Projects ("Agency"), the Agency vested by state law to carry out the duties and responsibilities imposed on the State of Nevada ("Nevada"), by the Nuclear Waste Policy Act ("NWPA"), as amended. 42 U.S.C. 10101, et seq. I have been the Executive Director of the Agency since 1983.

2. The primary responsibility of the Agency is to oversee and evaluate the U.S. Department of Energy's ("DOE's") programs (a) to characterize or otherwise study the proposed Yucca Mountain site in southern Nevada for the purpose of assessing its suitability as repository for high-level nuclear waste ("Yucca Mountain Project"), (b) to apply for all necessary licenses for the Yucca Mountain Project, and (c), if the Yucca Mountain Project is licensed, to construct and operate it as a repository for the disposal of high-level radioactive waste.

3. I hire and supervise consultants and scientists to assist and oversee DOE's evaluation of the Yucca Mountain site. My position also involves regularly tracking and

evaluating the Yucca Mountain Project. That is the basis of my personal knowledge of the matters stated in this Affidavit.

4. Nevada has a strong interest in protecting the health and safety of its citizens from radiological injuries and in protecting its lands and groundwater from radioactive contamination. The disposal of radioactive waste at Yucca Mountain will inevitably lead to increased radioactive doses to Nevada's citizens and to the contamination of the lands and the groundwater of Nevada with radioactive materials. Nevada's sovereign interests are injured because, under Nevada law, all groundwaters are owned by the people of Nevada and administered in trust by Nevada.

5. The Yucca Mountain Project would rank among the largest and most irreversible public works projects in history. Among other things, public lands in a corridor hundreds of miles long would have to be withdrawn so that waste could be transported to Yucca Mountain for disposal. These lands could not be used for public roads and bridges and other public infrastructure projects.

6. DOE’s plans to transport spent reactor fuel assemblies from their current reactor and other storage sites around the United States to Yucca Mountain would be the largest spent fuel transportation campaign in the history of the United States. This transportation campaign would create the risk of discharges of radioactive materials and land contamination, both within and outside of Nevada. Nevada emergency response resources would need be called upon, especially if a release occurs or is threatened in Nevada urban areas.

7. Another threat to Nevada arises from the intense negative perception and stigma associated with transportation to and disposal of high-level radioactive waste in Nevada. This could lead to losses of jobs and tax revenues.

Further affiant says not.

Robert R. Loux

The above-named affiant personally appeared before me this 12 day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: Sep 10, 2011

CASSIDY CLARK
NOTARY PUBLIC
STATE OF NEVADA
No.08-5389-12 My Appt. Exp. Sept. 10, 2011

Attachment 2

Affidavit of Charles J. Fitzpatrick

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF CHARLES J. FITZPATRICK

I, Charles J. Fitzpatrick, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Charles J. Fitzpatrick. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. The Nuclear Regulatory Commission (NRC) explained in a recent rulemaking defining a design basis threat (DBT) that a DBT considers "the [terrorist] tactics that have been observed in use." 72 Fed. Reg. 12705, 12708 (3/19/2007) [2007 DBT Rule]. Given the tactics in use on 9-11, this approach to developing the DBT would require a physical security DBT to include airborne attacks, including airborne attacks using a large commercial airliner. However, the Commission explained further that "the DBTs are based on adversary characteristics which a private sector security force can reasonably be expected to defend." 2007 DBT Rule at 12713. Thus the 2007 definition of the DBT was influenced by the Commission's judgment with respect to the proper division of responsibility between the public and private sectors. This consideration played an especially critical role in the Commission's deliberations with respect to airborne attacks. The Commission omitted airborne attacks from its DBT because "the airborne

threat is one that is beyond what a private security force can reasonably be expected to defend against." 2007 DBT Rule at 12710.

3. However, this consideration does not apply to DOE, an Executive Branch Agency with an important national security component and numerous well-established relationships with the President and other agencies such as the Departments of Homeland Security and Defense. Moreover, such limits would in any event have little or no bearing on consideration of design features to address airborne attacks that are within the control of applicants generally, especially at the pre-construction stage. Therefore, the Commission's consistent approach of considering "the [terrorist] tactics that have been observed in use" requires, in the case of Yucca Mountain, a design basis threat that includes airborne attacks, including attacks like those the occurred on 9-11.

4. The above constitutes a special circumstance applicable to the Yucca Mountain application. The specific aspect of the proceeding at issue is the DBT for Yucca Mountain. The application of existing DBT concepts to Yucca Mountain would not serve the purposes for which they were promulgated because, as explained above, one of those purposes, the need to recognize and ratify the limited role of the private sector in protecting against terrorist attacks, cannot be served when a federal agency applies for a construction authorization, and the other, protecting the public health and safety, would not be served by DBT that failed to include terrorist attacks observed in use for no valid reason.

5. Section 3 and Subsections 3.1-3.8 and 3.10-3.11 of the General Information portion of the LA, and similar sections, state that DOE's intends to conform its physical protection plan to existing regulations concerning security measures for physical protection. The applicable existing regulations are listed in the table at pg. 3-2. The critical, substantive

regulations are 10 C.F.R. §§ 73.2, 73.51, and 10 C.F.R. Part 73, Appendices B, C, and G.

6. The security measures for physical protection that DOE purports to apply are based on regulations the Commission has already declared to be inadequate to protect the common defense and security and the public health and safety. In 2007, the Commission wrote:

> The current regulations for . . . security for a [geologic repository operations area ("GROA")] were developed under a different threat environment, and the threat environment has changed, as have the plans for surface operations at a GROA. The NRC now believes that a new regulatory approach for protecting a GROA is necessary. In addition, the DOE has not set forth a final concept of operations document for the GROA; therefore, the types and forms of material to be handled and disposed of at a GROA have not been finalized. The current security . . . requirements for a GROA are not adequate to protect the common defense and security or the public health and safety.

72 Fed. Reg. 72,522, 72,524 (12/20/2007).

7. This Commission finding of inadequacy constitutes a special circumstance with respect to a subject matter of this proceeding, specifically DOE description of plans for physical protection of spent fuel and high-level waste at the Yucca Mountain repository. The specific aspect of DOE's description at issue is its reliance on regulations the Commission has determine to be inadequate. This application of 10 C.F.R. §§ 73.2, 73.51, and 10 C.F.R. Part 73, Appendices B, C, and G, in the special circumstances of this case, would not serve the purposes for which these rules were adopted, to protect the public health and safety and the common defense and security, because the implementation of inadequate regulations does not provide any assurance that the public health and safety and the common defense and security would in fact be protected.

8. Sections 4 and Subsections 4.1, 4.1.1 through 4.1.7, and 4.2 through 4.4 of the General Information portion of the LA, and similar subsections, state that DOE's intends to conform its material control and accounting program to existing regulations. These regulations

are listed in table at page 4-2. The critical substantive regulations are 10 C.F.R. §§ 72.72, 72.74, 72.76, 72.78, and 74.4.

9. The Federal Register notice cited above also included a Commission finding that existing regulations for material control and accounting applicable to Yucca Mountain are not adequate to protect the common defense and security or the public health and safety.

10. This Commission finding of inadequacy constitutes a special circumstance with respect to a subject matter of this proceeding, specifically DOE description of plans for material control and accounting at the Yucca Mountain repository. The specific aspect of DOE's description at issue is its reliance on regulations the Commission has determine to be inadequate. This application of 10 C.F.R. §§ 72.72, 72.74, 72.76, 72.78, and 74.4, in the special circumstances of this case, would not serve the purposes for which these rules were adopted, to protect the public health and safety and the common defense and security, because the implementation of inadequate regulations does not provide any assurance that the public health and safety and the common defense and security would in fact be protected.

Further, the affiant sayeth not.

Charles J. Fitzpatrick

Charles J. Fitzpatrick

The above-named affiant personally appeared before me this 10th day of December, 2008, and executed this affidavit.

SUSAN MONTESI
Notary Public
State of Texas
My Comm. Exp. 3-29-09

Susan Montesi

Notary Public

My Commission expires: 3-29-2009

Attachment 3

Affidavit of Michael C. Thorne

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of U.S. DEPARTMENT OF ENERGY License Application to Construct a Geologic Repository at Yucca Mountain	Docket No. 63-001

AFFIDAVIT OF MICHAEL C. THORNE

I, Michael C. Thorne, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Michael C. Thorne, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit.

3. Also within the Petition are numerous contentions relating to the TSPA. I hereby adopt as my own opinions the statements contained within Paragraph 6 of those specific contentions identified in Attachment C to this Affidavit.

4. I understand that attorneys for the State of Nevada will assign unique numbers to each of the contentions just prior to the filing of the Petition and will include those unique numbers in Attachments B and C.

Further, the affiant sayeth not.

M C Thorne

Michael C. Thorne

Signed before me on this 8' December 2008

Hilary Garnett

HILARY JANE GARNETT
NOTARY PUBLIC
13 STATION STREET
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ENGLAND

The above-named affiant personally appeared before me this 8th day of December, 2008, and executed this affidavit.

Hilary Garnett

Notary Public

My Commission expires: on death

HILARY JANE GARNETT
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ATTACHMENT A

CURRICULUM VITAE

MICHAEL C. THORNE

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Michael Charles Thorne

Qualifications: PhD FSRP Year of birth: 1950 Nationality: British

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Visiting Fellow at the Climatic Research Unit, School of Environmental Sciences, University of East Anglia
Fellow of the Society for Radiological Protection and a Past President of the Society
Member of the Editorial Board of the Journal of Radiological Protection
Member of the National Dose Assessment Working Group (NDAWG) and Chairman of the Habits Subgroup
Member of the Eco-ethics International Union
Consultant to the Institute for Energy and Environmental Research, Washington DC.
Quintessa Associate
Director, Mike Thorne and Associates Limited

ACADEMIC RESPONSIBILITIES

Formal supervision of two PhD students at the University of East Anglia:
P Burgess, Future Climatic and Cryospheric Change on Millennial Timescales: An Assessment using Two-dimensional Climate Modelling Studies, PhD awarded 1998.
M Hoar, Reconstructing Climate Gradients across Europe for the Last Glacial-interglacial Cycle, PhD awarded 2004.
Informal supervision of PhD students at the University of Edinburgh (development and retreat of ice sheets) and at Imperial College of Science, Technology and Medicine (radionuclide transport in vegetated soil columns – experimental studies and modelling interpretations).
Teaching on the MSc course on Environmental Radioactivity at the University of Surrey.
Teaching on the MSc course in Environmental Technology at Imperial College of Science, Technology and Medicine.
Supervision of Post-doctoral research activities at the Universities of East Anglia; University of Newcastle and Imperial College of Science, Technology and Medicine on behalf of various commercial clients.

CAREER HISTORY (Selection of Projects)

Mike Thorne and Associates Limited, 2001 onward

Development of Climate and Landscape Change Scenarios, Biosphere Factors and Characteristics of Potentially Exposed Groups for the LLWR near Drigg, West Cumbria
Client - Nexia Solutions Ltd

Project building on previous work for BNFL relating to the LLWR and for the NDA relating to vulnerabilities of various sites.

Radiological Impact of NORM Discharges to the Marine Environment
Client - Scotoil Services Ltd

Support to an appeal against a SEPA decision to curtail such discharges from North Pier, Aberdeen.

Development of Proposals for Setting Radiation Protection Standards based on Consideration of More Sensitive Individuals in a Population
Client – Institute for Energy and Environmental Research, Washington DC

Overall project review and development of techniques for calculating radiation doses to the early embryo from internally incorporated radionuclides.

Review of Impacts of Coastal Erosion at Hunterston
Client – ERM Limited

Evaluation of the potential radiological implications of coastal erosion on the VLLW pits at Hunterston Nuclear Power Station.

Advice on Dose Reconstruction
Client – S A Cohen & Associates for NIOSH

Advice on dose reconstructions for workers at DOE facilities from 1941 onward.

Advice on Effects of Radionuclides on Organisms other than Man
Client – Nuclear Safety Solutions Limited, Canada

Provision of guidance on dosimetry, reference levels and effects relevant to selected protected species.

Participation in Safety Assessment Studies for the Baita Bihor Repository, Romania
Client – Quintessa/for the European Union

Compilation of inventory data, shielding studies and development of both operational and post-closure safety cases.

Review of the Yucca Mountain Project
Client – State of Nevada

Co-ordination of technical activities involved in a review of the proposed License Application by US DOE for disposal of radioactive wastes at Yucca Mountain.

Co-ordination of biosphere research and participation in BIOCLIM
Client – UK Nirex Ltd (NDA/RWMD)

Co-ordination of research on climate change, ice-sheet development, near-surface hydrology and radionuclide transport, as well as participation in an international programme on the implications of climate change for radioactive waste disposal. Also includes development of new models for radionuclide transport in the biosphere and for the gas pathway.

Development of a Handbook on Radionuclide Behaviour in the Environment
Client – Serco Assurance

Development of a handbook for Environment Agency staff outlining the behaviour of a wide variety of radionuclides in terrestrial and aquatic environments.

Development of a Simplified Dose Assessment Model
Client – Serco Assurance

Development of a simplified spreadsheet-based dose assessment tool for use by Environment Agency staff in determining Authorisations.

Provision of Biosphere Advice
Client – Ciemat, Spain

Provision of advice on models and data relevant to geological disposal of radioactive wastes

Provision of Advice on Safety
Client – NNC Ltd/Defra

Provision of expert advice to the UK Committee on Radioactive Waste Management (CoRWM).

Effects of Radiation on Organisms Other Than Man
Client – AEA Technology/Serco Assurance

Study for ANDRA to identify appropriate indicator organisms and develop appropriate dosimetry and effects models for those organisms.

Member of the Site Investigation Expert Review Group (SIERG)
Client – SKB

Oversight reviews of site investigation activities and the associated research and assessment programmes.

Advice on the Short-, Medium- and Long-term Effects of Climate Change on Nuclear Licensed Sites
Client – BNFL and Nexia Solutions Ltd

Interpretation of results from the international BIOCLIM project in relation to decommissioning and solid radioactive waste management, with particular emphasis on the potential significance of sea-level changes. Review of information on coastal vulnerabilities at NDA sites.

Advice on Submarine Reactor Accidents and the Development of Detailed Emergency Planning Zones
Client – Electrowatt-Ekono

Assistance to MoD in revising emergency planning criteria in the light of recent changes of views on Emergency Reference Levels and other technical developments. Also studies on tritium analyses and migration from transfer tanks.

Review of Continuing Operational Safety Cases
Client – Electrowatt-Ekono

Review of COSRs developed by BNFL for contaminated land.

Development of a New Soil-Plant Model for use in Radiological Assessments
Client – Food Standards Agency/Quintessa

Development of the specification for a new soil-plant model (PRISM) to replace that implemented in the SPADE suite of codes (implementation of the model has been by Quintessa) and extension of that work to new models for ^{3}H and ^{14}C.

Review of Probabilistic Safety Assessment and Criticality Issues relating to a Proposed Surface Storage Facility for Spent Nuclear Fuel
Client – State of Utah

Review of the potential for criticality in breached storage casks and of the probability of breaching by aircraft impacts. Also, supervision of various criticality and radiation shielding calculations.

Development of Models for Radionuclide Transfers to Sewage Sludge and for Evaluating the Radiological Impact of Sludge applied to Agricultural Land
Client – Food Standards Agency

Includes a review of literature and the development and implementation of probabilistic models for such transfers.

Development of Biokinetic Models for Radionuclides in Animals
Client – Serco Assurance

Development of updated biokinetic models for use by the Food Standards Agency in their SPADE and PRISM modelling systems.

Review Studies for the Proposed Australian National Radioactive Waste Repository
Client – RWE NUKEM

Reviews of reports on animal transfer factors and of the potential effects of climate change on the repository plus development of a model for the biokinetics of the ^{226}Ra decay chain in grazing animals.

Development and Application of a Model for Assessing the Radiological Impacts of ^{3}H and ^{14}C in Sewage Sludge
Client – NNC Ltd

Development of a model based on physical, chemical and biochemical principles for the uptake of ^{3}H and ^{14}C into sewage sludge and their subsequent distribution and transport after application of the sludge to agricultural land.

Support for development of the Drigg Post-closure Radiological Safety Assessment
Client - BNFL

Support in the areas of FEP analysis, biosphere characterisation, human intrusion assessment and the effects of natural disruptive events. In addition, provision of advice of future research initiatives that should be pursued by BNFL.

Review of Parameter Values
Client – AEA Technology/Serco Assurance

Review of biosphere parameter values for use in the ANDRA assessment model AQUABIOS.

Development of a Database related to Emergency Planning
Client – AEA Technology (Rail)

Identification of relevant international, overseas and national legislation, regulations and guidance, and production of brief summaries of the documents.

Dose Reconstruction for Workers on a Uranium Plant
Client - McMurry and Talbot

Dose reconstruction for the plaintiffs in a case relating to the Paducah Gaseous Diffusion Plant.

Dose Reconstruction for a Worker Exposed to Pu and Am
Client – Pattinson and Brewer

Dose reconstruction for a worker exposed by a puncture wound in the finger while working at a glove box.

AEA Technology, 1998-2001

Revision of Exemption Orders Made Under the Radioactive Substances Act
Client – DETR

Review of requirements for revision and preparation of a draft text for the purposes of consultation.

Assessment of Remediation Options for Uranium Liabilities in Eastern Europe
Client - European Commission

Studies of remediation requirements relating to mines, waste heaps and hydrometallurgical plant in Bulgaria, Slovakia and Albania.

Evaluation of Unusual Pathways for Radionuclide Transport from Nuclear Installations
Client – Environment Agency

Review of literature and conduct of formal elicitation meetings to determine potential pathways and evaluate their radiological significance.

Support Studies on the Drigg Post-closure Performance Assessment
Client - BNFL

Support in the areas of FEP analysis, biosphere characterisation, human intrusion assessment and the effects of natural disruptive events. In addition, provision of advice of future research initiatives that should be pursued by BNFL.

Development of Models for the Biokinetics of H-3, C-14 and S-35 in Farm Animals
Client - FSA

Review of relevant literature, development of appropriate biokinetic models and implementation in stand-alone software.

Integration of Aerial and Ground-based Monitoring in the Event of a Nuclear Accident
Client - FSA

Desk-based review and simulation study designed to determine optimum monitoring strategies for different types of accidents.

Elicitation of Parameter Values for use in Radiological Impact Assessment Models
Client - FSA

Expert elicitation study to provide distributions of parameter values for use in the suite of assessment models currently used by the FSA for routine and accidental releases.

Biosphere Research Co-ordination and Assessment Studies
Client - United Kingdom Nirex Ltd

Continuation of a programme of work originally undertaken at Electrowatt Engineering (UK) Ltd

Site Investigation and Risk Assessment - Hilsea Lines
Client - Portsmouth City Council

Radiological assessment of a radium-contaminated site.

Electrowatt Engineering (UK) Ltd, 1987-1998

Development of a Siting Policy for Nuclear Installations: Harbinger Project and Follow-up Study
Client - HSE/NSD

Review of existing policy and development of alternatives as a precursor to application to a wide range of installations, not restricted to commercial reactors.

Support to the Rock Characterisation Facility Public Enquiry
Client - UK Nirex Ltd

Preparation of position papers and rebuttals of evidence.

Rongelap Resettlement Project
Client - Marshall Islands Government

Participation in an oversight committee evaluating the radiological safety of Rongelap in the context of resettlement by its evacuated community.

Evaluation of Inhalation Doses from Uranium
Client - Baron & Budd

Provision of expert witness support in a class action relating to environmental exposure from a uranium plant.

Biosphere Studies Relating to Drigg
Client - BNFL

Provision of advice on time-dependent biosphere modelling for the Drigg low-level radioactive waste disposal facility.

Radiation Doses to an Individual as a Consequence of Working on the San Onofre Nuclear Power Plant
Client - Howarth & Smith

Interpretation of personal and area monitoring data for legal purposes.

Interpretation of Uranium in Urine Data for the Fernald, Ohio Feed Materials Processing Center
Client - Institute for Energy and Environmental Research

Interpretation of urinalysis and lung counting data, and appearance as an expert witness in the associated trial.

Determination of Failure Probabilities for use in PRA
Client - Nuclear Installations Inspectorate

Development of new approaches to the use of Bayes Theorem in defining component failure probabilities for use in PRA when statistics on actual failures are limited.

Review of Inventory Information
Client - UK Nirex Ltd

Review of uncertainties in inventories of individual radionuclides.

ALARP Study of Options for the Treatment, Packaging, Transport and Disposal of Plutonium Contaminated Material
Client - UK Nirex Ltd

Use of multi-attribute utility analysis to establish which option is preferred.

Expert Judgement Estimation of Intrusion Model Parameters
Client - British Nuclear Fuels plc

Project Manager of a study assessing the risks of human intrusion into Drigg radioactive disposal site using expert judgement techniques.

Brainstorming Study of Risks Associated with Building Structures
Client - Building Research Establishment

Participation in a classification study of the health risks associated with buildings including both injuries and disease.

Radiological Consequences of Deferred Decommissioning of Hunterston A
Client - Scottish Nuclear Ltd

Project Manager of a study of the radiological impacts of groundwater transport of radionuclides, releases to atmosphere and intrusion.

Reviews of Safety Documentation
Client - UK Nirex Ltd

Review of safety related documentation for Packaging and Transport Branch.

The Sheltering Effectiveness of Buildings in Hong Kong
Client - Ove Arup & Partners

Project Manager of a study evaluating the shielding effectiveness of all types of building in Hong Kong for volume sources of photons in air and surface deposition sources.

Assessment of the Radiological Impact of Releases of Radionuclides from Premises other than Licensed Nuclear Sites
Client - Ministry of Agriculture, Fisheries and Food

Project Manager of a study to identify representative premises, obtain data on their releases of radionuclides and assess radiological impacts using a new methodology developed for the project.

Assessment of the Radiological Implications of Uranium and its Radioactive Daughters in Foodstuffs
Client - Ministry of Agriculture, Fisheries and Food

Project Manager of a review study of concentrations of uranium and its daughters in foodstuffs, taking local and regional variations in uranium concentrations in soils, sediments and waters into account.

Radionuclides in Sewage
Client - Her Majesty's Inspectorate of Pollution

Project Manager of a study including a desk review on alternative methods of disposal of sewage sludges, interpretation of monitoring data relating to radionuclide discharges from Amersham International to the public sewer system, development of a model for radionuclide transport in sewers, and collection and analysis of effluent, foul water, sediment, sludge and other samples suitable for use in model validation studies.

Accident Consequence Calculations
Client - Nuclear Installations Inspectorate

Project Manager of a study to assess the radiological consequences of various atmospheric releases using the MARC code.

Definition of Threshold Recording Levels for Drums of ILW

Client - UK Nirex Ltd

Project Manager of a study of the implications of post-closure radiological impacts of radioactive waste disposal in defining Threshold Recording Levels for radionuclides in individual waste drums.

Definition of Expert Judgment Exercises Relating to Nuclear Safety
Client - Commission of the European Communities

Project Manager for a study defining expert judgment exercises relating to conceptualisation, representation and input data specification. Included a comprehensive review of available formal expert judgment procedures, and mathematical and behavioural aggregation techniques.

Definition of Research Requirements Relating to the Use of Expert Judgment in Parameter Value Elicitation for Reactor Safety Studies in a UK Context
Client - Nuclear Safety Research Management Unit, HSE

Development of proposals for using combined behavioural and mathematical aggregation procedures in formal elicitations of expert judgment.

Development Priorities for the Drigg Technical Development Programme
Client - British Nuclear Fuels plc

Provision of detailed advice to BNFL on future design options, and research and development priorities, in relation to radioactive waste disposal at Drigg.

Channel Tunnel Safety Studies
Client - Channel Tunnel Safety Authority

Provision of advice and guidance on safety criteria appropriate to the Fixed Link, on the classes of Dangerous Goods that may properly be carried and on the overall characteristics of the proposed Safety Case.

Development of Societal Risk Criteria
Client - Marathon Oil

Interpretation of F-N curves in the context of the offshore oil/gas industry, taking risk aversion into account.

Impacts of Salt Dispersal on Plant Communities
Client - Sir William Halcrow

Evaluation of salt dispersal from a major road in winter in relation to adjacent Sites of Special Scientific Interest.

Offsite Consequence Assessments
Client - Nuclear Electric

Studies of the offsite radiological impacts of atmospheric and liquid releases of radioactive materials from Magnox stations.

Dry Run 3
Client - Her Majesty's Inspectorate of Pollution

Uncertainty and bias studies involving formal expert judgment procedures to develop a conceptual model of those factors and interrelationships which are of significance in determining the post-closure radiological impact of a deep geological repository for radioactive wastes. This project also included advice on data and models to be used for post-closure radiological assessments.

Radiological Assessments of Drigg
Client - British Nuclear Fuels plc

Project Manager for post-closure radiological impact assessments of the Drigg LLW disposal site. Also included specification and development of computer codes relating to the radiological impact of fires, releases of radioactive gases produced by microbial action and metal corrosion, and human intrusion.

Biosphere Co-ordination
Client - UK Nirex Ltd

Co-ordination of the UK Nirex Ltd Biosphere Research Programme from its inception, including requirements definition, technical management of all projects and QA surveillance as the Client's Representative.

Biosphere Support for the Nirex Disposal Safety Assessment Team
Client - AEA Technology

Development of approaches for assessing the radiological impact of releases of radionuclides to the biosphere, plus advice on radiological protection criteria, definition of individual risk, implications of conventionally toxic chemicals in wastes and a variety of other matters.

Evaluation and Radiological Assessment of Liquid Effluent Releases from Various Premises
Client - Her Majesty's Inspectorate of Pollution

Reviews of monitoring data and evaluations of radiological impact, primarily related to Harwell, Aldermaston, Capenhurst and Amersham International.

Evaluation of the Radiological Impact of Overseas Nuclear Accidents
Client - Her Majesty's Inspectorate of Pollution

Studies of the impact of potential overseas nuclear accidents on the UK, with emphasis on survey and monitoring requirements, and the selection of appropriate radiation detection equipment for monitoring.

Bilsthorpe Power Station
Client - British Coal/East Midlands Electricity

Preparation of an Environmental Statement with emphasis on atmospheric dispersion of SO_2 and NO_x.

Gas Generation in Radioactive Waste Disposal Facilities
Client - AEA Technology

Development of a coupled microbial degradation and corrosion model for gas generation in repositories for LLW and ILW.

Effects of Chernobyl on Drinking Water Supplies
Client - Her Majesty's Inspectorate of Pollution

Evaluation of the radiological implications of enhanced concentrations of radionuclides in water supplies in England and Wales subsequent to the Chernobyl accident.

Sea Disposal of Radioactive Wastes
Client - UK Nirex Ltd

Participation in an Environmental Impact Assessment of the proposed resumption of sea-dumping of radioactive wastes.

UK Research Related to Radioactive Waste Management
Client - Her Majesty's Inspectorate of Pollution

Identification of gaps in the UK national research effort related to radioactive waste management.

Research Requirements for Repository Design and Site Investigations
Client - UK Nirex Ltd

Review of research requirements for repository design and site investigations in relation to LLW and ILW disposal in near-surface and deep repositories.

International Commission on Radiological Protection, Sutton, Surrey, England, 1985-1986

Scientific Secretary responsible for arranging and minuting meetings, administrative arrangements, technical review of reports, editing of the Commission's journal, liaison with other international organisations and public relations.

ANS Consultants Ltd, Epsom, Surrey, England, 1979-1985

Reviews of data on the distribution at transport of radionuclides in terrestrial and aquatic ecosystems (see publications list).

Development of a dynamic model for radionuclide transport in agricultural ecosystems and implementation of the model on various microcomputer systems.

Photon and neutron shielding studies of radiochemical plant, together with area classification and ALARA studies.

A review of UK use of the criticality code MONK and other approaches to criticality safety assessment.

Radiological and conventional safety aspects of Magnox reactor decommissioning.

Development of metabolic models for inclusion in ICRP Publication 30.

Development of pharmacodynamic models for toxic chemicals.

Review of neutron activation analysis in studies of radionuclide transport in soils and plants.

Experimental studies on radionuclide transport in soils and plants using various photon-emitting radionuclides.

Support for DoE work on probabilistic risk assessment of LLW and ILW disposal.

Review of UK research requirements for HLW disposal.

Post-closure radiological impact assessment of the proposed LLW and ILW facility at Elstow, Bedfordshire.

Development of a generalised biosphere model for use in probabilistic risk assessments of solid radioactive waste disposal.

Initial development of a mathematical model for use in assessing the radiological impact of contaminated groundwater.

Development, computer implementation and comprehensive documentation of a model to calculate the radiological impact of intrusion into radioactive waste repositories.

Development of a general-purpose computer code for solving first-order differential equations using a hybrid Predictor-Corrector/Runge-Kutta method.

Studies on the potential radiological consequences of Magnox reactor accidents.

Medical Research Council Radiobiology Unit, Chilton, Didcot, Oxon, England, 1974-1979

Development of dosimetric and metabolic models for use in ICRP Publication 30.

Studies on the metabolism of plutonium in bone and relationships to blood flow.

Theoretical studies on radionuclide metabolism and dosimetry.

Development of techniques in neutron-induced autoradiography and alpha imaging.

Image analysis studies of plutonium in bone, uranium in lungs, lysosomal inclusions in cells and heterochromatin.

Studies on the clearance of inhaled UO_2.

Alpha spectroscopy in support of toxicity studies with Ra-224.

Data analysis in connection with experimental animal studies on the potential efficacy of neutron therapy using 42 MeV neutrons.

University of Sheffield, 1971-1974

Experimental studies on the reaction $\gamma + p \rightarrow \pi^o + p$ at photon energies between 1 and 3 GeV, using a linearly polarised photon beam.

SELECTION OF PUBLICATIONS

A measurement of the beam asymmetry parameter for neutral pion photoproduction in the energy range 1.2 - 2.8 GeV. P.J.Bussey, C. Raine, J.G. Rutherglen, P.S.L. Booth, L. Carroll, G.R. Court, A.W. Edwards, R. Gamet, C.J. Hardwick, P.J. Hayman, J.R. Holt, J.N. Jackson, J. Norem, W.H. Range, F.H. Combley, W. Galbraith, V.H. Rajaratnam, C. Sutton and M.C. Thorne. London Conference (1974) Abstract 997.

The measurement of the polarisation parameters Σ, P and T for positive pion photoproduction between 500 and 1700 MeV. P.J. Bussey, C. Raine, J.G. Rutherglen, P.S.L. Booth, L.J. Carroll, P.R. Daniel, C.J. Hardwick, J.R. Holt, J.N. Jackson, J.H. Norem, W.H. Range, F.H. Combley, W. Galbraith, V.H. Rajaratnam, C. Sutton, M.C. Thorne and P. Waller. Nuclear Physics, B104, (1976) 253-276.

The polarised beam asymmetry in photoproduction of eta mesons from protons 2.5 GeV and 3.0 GeV. P.J. Bussey, C. Raine, J.G. Rutherglen, P.S.L. Booth, L.J. Carroll, P.R. Daniel, A.W. Edwards, C.J. Hardwick, J.R. Holt, J.N. Jackson, J. Norem, W.H. Range, W. Galbraith, V.H. Rajaratnam, C. Sutton, M.C. Thorne and P. Waller. Physics Letters, 61B, (1976) 479-482.

Aspects of the dosimetry of plutonium in bone. M.C. Thorne. Nature, 259, (1976) 539-541.

The toxicity of Sr-90, Ra-226 and Pu-239. M.C. Thorne and J. Vennart. Nature 263, (1976) 555-558.

Radiation dose to mouse testes from Pu-239. D. Green, G.R. Howells, E.H. Humphreys and J. Vennart with Appendix by M.C. Thorne. Published in "The Health Effects of Plutonium and Radium", Ed. W.S.S. Jee, (J.W. Press, Salt Lake City, Utah, 1976).

The distribution and clearance of inhaled uranium dioxide particles in the repository tract of the rat. Donna J. Gore and M.C. Thorne. In "Inhaled particles IV", Ed. W.H. Walton, (Pergamon Press, Oxford, 1977) pp. 275-284.

Theoretical aspects of the distribution and retention of radionuclides in biological systems. M.C. Thorne. J. Theor. Biol., 65, (1977) 743-754.

Aspects of the dosimetry of emitting radionuclides in bone with particular emphasis on Ra-226 and Pu-239. M.C. Thorne. Phys. Med. Biol., 22, (1977) 36-46.

A new method for the accurate localisation of Pu-239 in bone. D. Green, G. Howells and M.C. Thorne. Phys. Med. Biol., 22, (1977) 284-297.

The measurement of blood flow in mouse femur and its correlation with Pu-239 deposition. E.R. Humphreys, G. Fisher and M.C. Thorne. Calcif. Tiss. Res., 23, (1977) 141-145.

The distribution of plutonium-239 in the skeleton of the mouse. D. Green, G.R. Howells, M.C. Thorne and J. Vennart. In "Proceedings of the IVth International Congress of the International Radiation Protection Association Vol. 2 (Paris 1977).

The visualisation of fissionable radionuclides in rat lung using neutron induced autoradiography. D.J. Gore, M.C. Thorne and R.H. Watts. Phys. Med. Biol., 23 (1978) 149-153.

Lymphoid tumours and leukaemia induced in mice by bone-seeking radionuclides. J.F. Loutit and T.E.F. Carr with an appendix by M.C. Thorne. Int. J. Radiat. Biol., 33, (1978) 245-263.

Plutonium-239 deposition in the skeleton of the mouse. D. Green, G.R. Howells and M.C. Thorne. Int. J. Radiat. Biol., 34, (1978) 27-36.

Imaging of tissue sections on Lexan by alpha-particles and thermal neutrons; an aid in fissionable radionuclide distribution studies. D. Green, G.R. Howells, M.C. Thorne and R.H. Watts. Int. J. Appl. Radiat. Isotopes, 29, 285-295 (1978).

Analytical techniques for the analysis of multi-compartment systems. M.C. Thorne. Phys. Med. Biol., 24, 815-817 (1979).

The initial deposition and redistribution of Pu-239 in the mouse skeleton: implications for rodent studies in Pu-239 toxicology. D. Green, G.R. Howells and M.C. Thorne. Br. J. Radiol., 52, 426-427 (1979).

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Quantitative microscopic studies of the distribution and retention of Pu-239 in the ilium of the female CBA mouse. D. Green, G.R. Howells and M.C. Thorne. Int. J. Radiat. Biol., 36, 499-511 (1979).

Techniques for studying the distribution of alpha emitting and fissionable radionuclides in histological lung sections. T. Jenner and M.C. Thorne. Phys. Med. Biol., 25, 357-364 (1980).

Morphometric studies of mouse bone using a computer-based image analysis system. D. Green, G.R. Howells and M.C. Thorne. J. Microscopy, 122, 49-58 (1981).

A semi-automated technique for assessing the microdistribution of ^{239}Pu deposited in bone. D. Green, G.R. Howells and M.C. Thorne. Phys. Med. Biol., 26, 379-387 (1981).

Radionuclide distribution and transport in terrestial and aquatic ecosystems, Volumes 1 to 6. P.J. Coughtrey, M.C. Thorne et al. A.A. Balkema, Rotterdam 1983-1985.

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Studies on the mobility of radioisotopes of Ce, Te, Ru, Sr and Cs in soils and plants. P.J. Coughtrey, M.C. Thorne, D. Jackson and G.F. Meekings. In: CEC Symposium on the Transfer of Radioactive Materials in the Terrestial Environment Subsequent to an Accidental Release to Atmosphere. Dublin, April 1983.

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Pharmacodynamic models of selected toxic chemicals in man. Vol. 2. Routes of intake and implementation of pharmacodynamic models. A.D. Smith and M.C. Thorne. MTP Press. Lancaster 1986.

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A model for evaluating radiological impacts on organisms other than man for use in post-closure assessments of geological repositories for radioactive wastes, M C Thorne, M Kelly, J H Rees, P Sànchez-Friera and M Calvez, J. Radiol. Prot., 22, 249-277, 2002.

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A Strategy for Biosphere Research to support Safety Assessment Modelling, A P Butler, S A Mathias, and M C Thorne, Mike Thorne and Associates Limited Report to UK Nirex Limited MTA/P0011A/2006-1: Issue 1, August 2006.

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A Guide to the Spreadsheet Model used for Groundwater and Well Calculations for Generic Performance Assessments, M C Thorne, Mike Thorne and Associates Limited Report to UK Nirex Limited MTA/P0011C/2006-4: Issue 2, March 2007.

A Summary of Input Data for use in Intrusion Calculations in a Generic Performance Assessment, M C Thorne, Mike Thorne and Associates Limited Report to UK Nirex Limited MTA/P0011C/2005-2: Issue 4, March 2007.

A Point-scale Model for Cl-36 Transport in Soils and Plants, M C Thorne, Mike Thorne and Associates Limited Report to UK Nirex Limited MTA/P0011B/2006-1: Issue 3, March 2007.

LLWR Lifetime Project: R&D on Climate Change and Site Evolution, Mike Thorne and Associates Limited Report to Nexia Solutions Ltd, MTA/P0022/2007-1: Issue 2, March 2007.

Sensitivity Studies on Cl-36 Transport in Soils and Plants for Use in the BIOPROTA Model Inter-comparison Project, Mike Thorne and Associates Limited Report to the Nuclear Decommissioning Authority, MTA/P0011B/2007-1: Issue 1, May 2007.

ATTACHMENT B

Contentions Adopted By **Michael C. Thorne** (Paragraph 5) In Accordance With Affidavit
NEV-SAFETY-08
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ATTACHMENT C

Contentions Adopted By **Michael C. Thorne** (Paragraph 6) In Accordance With Affidavit
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Attachment 4

Affidavit of Adrian H. Bath

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF ADRIAN BATH

I, Adrian Bath, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Adrian Bath, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Adrian H Bath

Adrian Bath

The above-named affiant personally appeared before me this 15 day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: on death

C N Cullen
Notary Public
Nottingham, England

ATTACHMENT A

CURRICULUM VITAE

ADRIAN BATH

Dr Adrian Bath

Capabilities, Qualifications and Experience

Capabilities	Environmental geochemistry and contaminant chemistry in groundwaters, the surface environment and engineered systems. Services for clients in radioactive waste management, hazardous waste management, environmental remediation, water resources and environmental quality.	
Qualifications	BA (Chemistry) and PhD (Isotope Geochemistry), Oxford University CGeol (Chartered Geologist)	
Affiliations	Fellow of the Geological Society, UK; Member of the Geochemical Society, USA; Member of the International Association of Hydrogeologists Member of the International Association of Geochemistry	
Contact	E: abath@intellisci.co.uk T: +44-(0)1509-889229 M: +44-(0)7769-712233	
Employment	2000 to present	Intellisci Ltd, Loughborough, UK Independent geoscientific consultant
	1994 to 1999	Golder Associates (UK) Ltd, Nottingham, UK Principal geochemistry consultant
	1974 to 1994	British Geological Survey, Keyworth, UK Group manager, environmental and waste management group

SUMMARY OF EXPERIENCE

- Environmental geochemistry and contaminant chemistry in groundwaters, the surface environment and engineered systems.
- Services for clients in radioactive waste management, hazardous waste management, environmental remediation, water resources and environmental quality.
- 33 years as research scientist in groundwater chemistry, hydrogeology, and environmental chemistry.
- 24 years in applying geochemistry in radioactive waste management, environmental behaviour of radionuclides, and safety assessment of waste repository sites.
- Providing scientific advice and services to European, American and Japanese radioactive waste management and nuclear regulatory organisations.
- Planning and interpretation of site investigations for repositories and underground laboratories in crystalline rock and clay rock.
- Geochemical modelling of radionuclides in engineered barriers, groundwater systems around repositories, and in contaminated construction materials.
- Specialist problem-solving inputs to projects concerning hazardous waste management, landfill disposal, groundwater contamination and geotechnics.
- Scientific management and review activities in projects on hydrogeochemistry, isotope hydrology, groundwater flow, solute transport, groundwater/soils contamination, and palaeohydrogeology.
- Lead author of many scientific publications and consultancy reports on the applications of geochemistry in radioactive waste management and other areas of groundwater and environmental science.
- Expert adviser/reviewer to national/international organisations, peer reviewer for scientific journals, conference organiser, external examiner for MSc and PhD at European universities.

PROJECTS

- **NDA–Radioactive Waste Management Directorate** (2008-ongoing)

Member of high-level Geosphere Characterisation Advisory Panel (GeoCAP). Provide preview and review of activities being undertaken with the geosphere characterisation project, and provide ad hoc advice of geoscientific aspects of characterising sites for potential geological disposal facility. Additional framework contract to provide scientific consultancy services to support implementation of UK's geological disposal facility, specifically to represent NDA-RWMD on high-level specialist groups.

- **Low Level Waste Repository Ltd (LLWR)** (2007-ongoing)

Member of Peer Review group, focusing on geochemistry and hydrogeology. Review documents prepared by LLWR and contractors for authorisation of repository at Drigg, including EA's schedule 9 requirements, radiological capacity, design of vault 9, R&D programme, other work leading to post-closure safety case in 2011.

- **NDA–Radioactive Waste Management Directorate** (2006-2008)

Responsible for geochemistry in GeoCORE project for developing strategy, capability and technical plans for characterising potential repository sites in the UK. Contribute to strategic plan, produce information requirements for geochemistry and hydrogeology. Specify technology requirements and research needs. Review and update Nirex geosphere characterisation project documentation.

- **STUK (Radiation and Nuclear Safety Authority), Helsinki, Finland** (2007-ongoing)

Member of ONKALO expert group (SONEX). Responsible for review of geochemistry and hydrogeology outputs from Posiva's underground rock characterisation excavation (ONKALO). Commentary on site investigation strategies with focus on the geochemical and hydrogeological data requirements for a deep repository performance assessment and on the general arguments for site suitability and safety.

- **Nagra Switzerland and University of Berne (for the Nuclear Energy Agency)** (2007-2008)

CLAYTRAC project for the NEA's 'Clay Club' special interest group on clay rock as repository hosts. Compilation and quality review of geochemical and isotopic data from clay rock investigations at potential repository sites and at underground laboratories worldwide. Assistance to modellers at University of Berne in setting up parameters and boundary conditions for diffusion-advection transport modelling of natural solute and isotope profiles. The aim of the project is to review natural tracer evidence for solute transport processes in clay rock repository hosts.

- **Golder Associates GmbH for Bundesamt für Strahlenschutz (BfS), Germany** (2007-2008)

Compilation of information on strategies for investigation of sites for deep repositories and underground laboratories. Data for borehole drilling, hydrogeological testing and hydrochemical sampling. Description of testing methods and outcomes with discussions of site-specific strategic and logistical issues. Advice to BfS on applicability and lessons learned for German site selection and investigations according to AkEnd recommendations and criteria.

- **DEFRA and Committee on Radioactive Waste Management, UK** (2005-2007)

Provision of expert advice and input at workshops of the UK government's Committee on Radioactive Waste Management (CoRWM, 2005-6). Production of methods for technical scoring of radioactive waste disposal options. Participation in options scoring sessions. Attendance as specialist panel member to assist CoRWM discussion on geological disposal options and safety. Member of Defra's Site Screening Criteria Proposals Group (2007). Drafting of technical annexe on geoscientific site screening for government consultation on a framework for implementing geological disposal in the 'Managing Radioactive Waste Safely' programme.

- **European Commission, Brussels** (2005-2008)

Expert peer reviewer for EC of annual progress in the ACTINET project (FP6 Network of Excellence for Actinide Sciences). Review progress reports and technical outputs from work packages on actinide chemistry and geochemistry. Attend annual review presentations and discussions with project management team, executive board and research leaders. Make recommendations to EC.

- **State of Nevada, USA via Egan, Fitzpatrick & Malsch PLLC** (2004-ongoing)

Assistance in assessing the proposed USDOE HLW and spent fuel repository at Yucca Mountain, Nevada. Review of geochemical, hydrogeological and engineered barrier chemistry designs, analytical and process model reports, and other documentation.

- **Golder Kft. and PURAM (Hungarian Radioactive Waste Authority), Hungary** (2004-2006)

Development of a reactive transport model using the PHREEQC geochemical model for radionuclide solubility and sorption in engineered barrier of repository concept in fractured rocks. Simulation of long-term evolution of repository system and provision of radionuclide transport parameters for safety analysis. Estimation of hydrogeological, geochemical and radionuclide transport parameters for a preliminary safety analysis of potential spent fuel repository in a clay rock.

- **SSM (Swedish Radiation Safety Authority, previously SKI), Stockholm, Sweden** (2001-ongoing)

Member of INSITE group advising on SSM's review of SKB investigations at proposed sites for a deep HLW repository. Advice to SSM on geochemical data requirements and evaluation of priorities in safety case of repository in crystalline rock. Review of repository implementer's strategic plans, scientific methods, designs, Site Descriptive Models and preliminary safety assessments SR-Can and SR-Site. Specifications for geochemical data requirements from site characterisation. Study of geochemical and isotopic methods of investigating groundwater stability.

- **UK Nirex Ltd** (2000-2005)

Provision of consultancy services for the planning of site characterisation at potential repository sites, focusing especially on sampling and testing for geochemistry and hydrogeology. Development of methods for interpretation of hydrochemical and isotopic data, geochemical modelling and regional groundwater modelling.

- **DEFRA, UK** (2005)

Review and evaluation of the 2001 UK Radioactive Waste Inventory including appendices for MoD and BNFL stocks.

- **Quintessa K.K. for NUMO, JAEA and RWMC, Japan** (2004-2006)

Evaluation of methods for measuring and interpreting in situ groundwater compositions from data obtained in boreholes during site investigations. Compilation of hydrochemical data and groundwater flow information for low-permeability, low-flow groundwater settings for potential repository sites. Review of a classification system using Evidence Support Logic for assessing the quality of hydrogeochemical data from the Tono/Mizunami area.

- **Brenk Systemplanung GmbH, Aachen, Germany** (2002-2003)

Study of radioactive contamination by concrete in nuclear facilities and of subsequent releases on reuse or disposal after decommissioning and dismantling. Theoretical study and literature review of locations of radionuclides in contaminated concrete. Development of numerical models for release of radionuclides in various scenarios, construction of source terms for radiological dose assessments and comparisons with clearance levels.

- **European Commission & UK Nirex Ltd** (2002-2005)

PADAMOT (Palaeohydrogeological Data Analysis and Model Testing) research project in the 5th Framework Programme of the EU with Nirex (UK), SKB (Sweden), ENRESA (Spain) RAWRA (Czech Republic) and BGS (UK). Investigation of methods for assessing stability of groundwater conditions for long-term safety of radioactive waste repositories. Development of geochemical models for water-rock reaction and secondary mineralisation in shallow and deep groundwaters.

- **Mont Terri Project International Consortium, Switzerland** (2000-2002)

Interpretation and reporting of isotopic, geochemical and hydrogeological data from borehole investigations in mudrocks at Mont Terri underground laboratory in Switzerland. Joint editor of a major synthesis of geochemical data and interpretations. Interpretation of isotopic and geochemical data for evolution of clay pore waters.

- **SKB (Swedish Radioactive Waste Company), Stockholm, Sweden** (2000-2001)

Scientific peer review of international research project on coupling of hydrochemical and hydrogeological models at Äspö underground laboratory, Sweden.

- **European Commission, Brussels, Belgium and UK Nirex Ltd, Harwell, UK** (1997-2000)

Co-ordination and management of EQUIP research project on geochemical and mineral indicators of groundwater history in low permeability terrain for repository siting for EC R&D Programme on Radioactive Waste Management. European partners: Posiva (Finland), SKB (Sweden), Andra (France), Enresa (Spain), UK Nirex, Environment Agency.

- **Enresa (Spanish Radioactive Waste Company), Madrid, Spain** (1996-1998)

Chemical modelling of bentonite backfill and of radionuclide solubilities for spent fuel disposal concepts in granite and clay rocks. Geochemical modelling of sorption and solubilities of radionuclides and providing parameters for safety analyses.

- **International Atomic Energy Agency, Vienna, Austria** (1996)

Expert consultancy in evaluating the use of natural analogue information to support geochemical and radionuclide transport models for geological repositories

- **UK Nirex Ltd, Harwell, UK** (1991-1998)

Lead investigator in geochemistry and hydrogeology tasks for safety assessment of deep radioactive waste repository at Sellafield, UK. Design and specification of data acquisition. Interpretation of geochemical data for site characterisation and safety assessment. Technical tasks include geochemical modelling, isotope hydrology, baseline data assessment, evaluation of uncertainties in geochemical data for safety analyses.

SELECTED REPORTS AND PUBLICATIONS

- Apted, M., Arthur, R., Bath, A., Mazurek, M., Rutqvist, J., Saario, T., Saarnisto, M., Stephansson, O. and Tsang, C-F. (2008) Review of Posiva 2006-05: Expected evolution of a spent nuclear fuel repository at Olkiluoto. Report to STUK, Helsinki, Finland. April 2008.
- Styles, P., Wheater, H. and others (2007) Sub-surface exclusion criteria for geological disposal: Joint report of the Criteria Proposals Group (CPG) and the Criteria Review Panel (CRP). Appendix in the Managing Radioactive Waste Safely (MRWS) consultation and 2008 White Paper. Defra.
- Bath, A. and Metcalfe, R. (2008) NDA-RWMD Geosphere Characterisation Project: Data Acquisition Report: Groundwater Sampling and Analysis Techniques. Quintessa Report QRS-1421A-R2 v1.1, May 2008.
- Mazurek, M., Alt-Epping, P., Bath, A., Gimmi, T. and Waber, H.N. (2008) CLAYTRAC Project: Natural tracer profiles across argillaceous formations – review and synthesis. Report NEA No 6253, Radioactive Waste Management, Nuclear Energy Agency, OECD, Paris. 375 pp.
- Bath, A. and Hermansson, H-P. (2007) Impacts of Future Glaciations on Geochemical Conditions at Repository Depth: Review of SKB's Approach. Report by Intellisci Ltd and Studsvik AB for SKI Stockholm. 63 pp.

- Mazurek, M., Bath, A., Niemi, A., Stephansson, O. and Tirén, S. (2007) Consolidated review of Olkiluoto Site Description 2006, Posiva 2007-03. Review report by SONEX team for STUK, Helsinki, Finland.
- Mazurek, M., Alt-Epping, P., Gimmi, T., Waber, H.N., Bath, A., Buschaert, S. and Gautschi, A., (2007) Tracer profiles across argillaceous formations: a tool to constrain transport processes. Extended abstract, Procs 12th Intl Symp on Water-Rock Interaction, WRI-12, 13-18 Aug 2007, Kunming, China.
- Stephansson, O., Bath, A., Niemi, A. and Tirén, S. (2007) Review of Posiva´s TKS-2006 programme. Review report by Site SONEX team for STUK, Helsinki, Finland.
- Mazurek, M., Alt-Epping, P., Bath, A., Buschaert, S., Gautschi, A., Gimmi, T. and Waber, H.N. (2007) CLAYTRAC project: evaluation of tracer profiles across argillaceous formations. Abstract, 3rd International Meeting on Clays in Natural and Engineered Barriers for Radioactive Waste Confinement, Lille, 17-20 Sept 2007. Andra, Châtenay-Malabry, France
- Bath, A. (2007) Interpreting the evolution and stability of groundwaters in fractured rocks. In: Groundwater in Fractured Rocks (J Krásný & JM Sharp, eds), IAH Selected Papers on Hydrogeology Volume 9, Intl Assoc of Hydrogeologists, pp 261-274. Taylor & Francis, London..
- Bath, A (2007) Geochemistry Strategy and Site Investigation Flow Diagrams for GeoCORE. Report 0607.17 by Intellisci Ltd for UK Nirex, March 2007. 47 pp.
- Chapman, N., Wilmot, R. and others (2007) Expert Evaluation of the Swedish Nuclear Fuel and Waste Management Company's Safety Assessment SR-Can Report of the Site Investigation Group. Report by INSITE/OVERSITE to SKI, Stockholm, June 2007. 41 pp.
- Bath, A. and Hermansson, H-P. (2007) Variability and Uncertainties of Key Hydrochemical Parameters for SKB Sites. SKI Report 2007:03, by Intellisci Ltd and Studsvik AB for SKI Stockholm. 56 pp.
- Metcalfe, R., Crawford, M.B., Bath, A.H., Littleboy, A.K., Degnan, P.J. and Richards, H.G. (2007) Characteristics of deep groundwater flow in a basin marginal setting at Sellafield, northwest England: 36Cl and halide evidence. Applied Geochemistry, 22, 128-151.
- England, G.L., Gillespie, M.R., Milodowski, A.E., Haszeldine, R.S., Degnan, P.J., Bath, A. and Macleod, G. (in press) Palaeo-redox conditions of groundwater during glaciation at Sellafield, UK revealed by SIMS analysis of REE in fracture-fill calcite. Accepted for publication in Chemical Geology.
- Bath, A. (2006) Contributions to Design and Performance Assessment of a Proposed LILW Repository at Bátaapáti, Hungary. Final Report, Task 1: Geochemistry FEPs (Features, Events and Processes). Report prepared for Golder Associates (Hungary) Kft. 49 pp.
- Bath, A., Richards, H., Metcalfe, R., McCartney, R., Degnan, P. and Littleboy, A. (2006) Geochemical Indicators of Deep Groundwater Movements at Sellafield, UK. In: Special vol. 'Geochemical Aspects of Radioactive Waste Disposal' (guest eds. J-B Peyaud, T de Putter and I McKinley). Journal of Geochemical Exploration, 90, 24-44.
- Darling, W.G., Bath, A.H., Gibson, J.J. and Rozanski, K. (2006) Isotopes in Water. Chapter 1 in 'Isotopes in Palaeoenvironmental Research' (Leng, M.J., ed.), pp 1-66, Developments in Paleoenvironmental Research, Vol. 10, Springer, Dordrecht, 307pp.
- Bath, A. (2006) Geochemical Investigations of Groundwater Stability. SKI Report 2006:12, by Intellisci Ltd for SKI Stockholm. 83 pp.
- Deissmann, G., Bath, A., Jefferis, S., Thierfeldt, S. and Wörlen, S. (2006) Development and application of knowledge-based source-term models for radionuclide mobilisation from contaminated concrete. In: Van Iseghem, P. (ed.): Scientific Basis for Nuclear Waste Management XXIX. Mat. Res. Soc. Symp. Proc. 932: 259-266.
- Goldsworthy, M., Dankó, G., Kovacs, L., Bath, A. and Frigyesi, F. (2005) Initial performance assessment for a deep geological repository for HLW at Boda. Proceedings of ICEM'05: 11th International Conference on Radioactive Waste Management and Environmental Remediation, 5-8 Sept 2005, Glasgow, Scotland. 6pp. American Society of Mechanical Engineers, Tucson
- Degnan, P., Bath, A., Cortés, A., Delgado, J., Haszeldine, S., Milodowski, A., Puigdomenech, I., Šilar, J., Torres, T. and Tullborg, E-L. (2005) PADAMOT: Project Overview Report. PADAMOT Project – EU FP5 Contract No FIKW-CT2001-20129. 85 pp. UK Nirex Ltd., Harwell.
- Bath, A. (2005) Technical Review of the 2001 United Kingdom Radioactive Waste Inventory: Main Report and Detailed Reports for BNFL Wastes and MoD Wastes (DEFRA Reports DEFRA/RAS/02.004, 02.005, 02.009 and Nirex Reports N/042, N/043, N/047). Report by Intellisci Ltd for DEFRA, London, 14pp. March 2005.
- Bath, A., Goldsworthy, M., Dankó, G. and Kovacs, L. (2005) Parameters for pre-investigation assessment of a fractured claystone as a repository host in Hungary. Abstract, Intl Meeting on Clays in Natural and Engineered Barriers for Radioactive Waste Confinement, Tours, France.

- Bath, A. and Jefferis, S. (2004) Performance of Concrete in the Source Term for Performance Assessment of the Proposed LILW Repository, Bátaapáti, Hungary: Geochemical and Geotechnical Considerations. Report for Golder Associates (Hungary) Kft. May 2004, 92pp.
- Bath, A. (2004) Pre-investigation Estimates for Hydrogeological, Geochemical and Radionuclide Transport Parameters for the Boda Claystone (Host Formation for Proposed Spent Fuel Repository), Pécs, Hungary. Report for Golder Associates (Hungary) Kft. June 2004, 37pp.
- Bath, A. and C.P. Jackson (2004) Brines at the West Cumbrian Coast: Technical Note and Supplementary Memorandum on Comparison of Hydrodynamic and Geochemical Water Ages. Reports by Intellisci Ltd and Serco Assurance for Nirex, February 2004. 28 pp & 11pp.
- Bath, A., Deissmann, G. and Jefferis, S. (2003) Radioactive contamination of concrete: uptake and release of radionuclides. Proceedings of ICEM'03: 9th International Conference on Radioactive Waste Management and Environmental Remediation, 21-25 Sept 2003, Oxford, England. ICEM03-4814, 8pp. American Society of Mechanical Engineers, Tucson.
- Bath, A. and Strömberg, B. (2003) Geochemical Indicators of Groundwater Stability. Proceedings of MRS 2003, Kalmar, Sweden. Scientific Basis for Radioactive Waste Management XXVII, Volume 807, pp 773-778. Materials Research Society, Boston, USA.
- Bath, A. and Jefferis, S. (2003) Release of Radionuclides from Concrete and Building Rubble from the Dismantling of Nuclear Installations. Task 4: Release Behaviour of Radionuclides from Concrete Material. Final Report – February 2003. Report for Brenk Systemplanung GmbH, Aachen, Germany.
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ATTACHMENT B

Contentions Adopted By **Adrian Bath** In Accordance With Affidavit
NEV-SAFETY-42
NEV-SAFETY-43
NEV-SAFETY-44
NEV-SAFETY-49
NEV-SAFETY-55
NEV-SAFETY-56
NEV-SAFETY-57
NEV-SAFETY-58
NEV-SAFETY-59
NEV-SAFETY-60
NEV-SAFETY-67
NEV-SAFETY-70
NEV-SAFETY-71
NEV-SAFETY-78
NEV-SAFETY-79
NEV-SAFETY-113
NEV-SAFETY-114
NEV-SAFETY-115
NEV-SAFETY-116

Attachment 5

Affidavit of Allen Messenger

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF ALLEN L. MESSENGER

I, Allen L. Messenger, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Allen L. Messenger, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Allen L. Messenger

Allen L. Messenger

The above-named affiant personally appeared before me this 11 day of December, 2008, and executed this affidavit.

VICKI C. HILTON
MY COMMISSION EXPIRES
June 5, 2010

Vicki C Hilton

Notary Public

My Commission expires: June 5, 2010

ATTACHMENT A

CURRICULUM VITAE

ALLEN L. MESSENGER

ALLEN L. MESSENGER, P.E.

PERSONAL: Born May 16, 1952, Corpus Christi, Texas

EDUCATION: M.S. CIVIL ENGINEERING, Texas A&M University, 1979
B.S. BIOLOGY, Minors in Math, Chemistry, Computer Science, Stephen F. Austin State University, 1975

PRINCIPAL, A M Environmental, LLP, Austin, Texas, 2002 - Present
PRESIDENT, A M Environmental, Inc. Austin, Texas 1989 – 2001
INDEPENDENT PROFESSIONAL ENGINEER, Messenger Environmental Service, 1986 – 1989
SENIOR STAFF ENGINEER, Espey Huston & Associates, 1985 - 1986 HEAD, Disposal Facilities Unit, Texas Department of Water Resources (TDWR), Austin, 1981 - 1985
PERMIT WRITER, Industrial Solid Waste Section, TDWR, Austin, 1980 - 1981
PROJECT MANAGER, Hays & Lindsey, Austin, 1978 - 1980
CONSULTANT, Oceanography International, College Station, 1977-1978
RESEARCH ASSISTANT, Texas A&M University, 1975 - 1978
ASSISTANT DIRECTOR OF AIR AND WATER POLLUTION CONTROL, City of Nacogdoches, 1975

WORK EXPERIENCE

Mr. Messenger has provided consulting environmental engineering services for over 20 years, specializing in industrial waste management/permitting and related soil and water contamination. Major projects include site selection and permitting a green field commercial industrial and hazardous waste landfill facility, project management of license/permit applications for: a Class C radioactive materials storage and processing facility; a radioactive waste disposal application, permitting: TSCA storage facilities; commercial hazardous waste landfills; a hazardous waste and TSCA processing and incinerator complex; container storage; fuel blending and storage; stabilization; medical waste incineration; industrial waste water discharges; a non-attainment permit for NOx and other air emissions exemptions and permits.

Current and recent projects range from providing consulting expert and expert witness services for clients including the Nuclear Waste Project Office of the State of Nevada and the New Mexico Attorney General's Office regarding the proposed Yucca Mountain and Louisiana Energy Services facilities, respectively to the investigation and remedial design of soil and groundwater contaminated with hazardous and non-hazardous substances. Mr. Messenger also designs, registers and permits industrial waste management facilities and stormwater pollution control systems.

While employed by the TDWR, as the Head of the Disposal Facilities Unit, he and his staff were responsible for: development of land disposal regulations including regulations and guidance on design, siting and groundwater monitoring of hazardous and non-hazardous waste landfills; review and technical approval of proposed and existing hazardous and non-hazardous industrial landfills throughout the State of Texas; concurrent review of new municipal landfills proposed in the State of Texas; review and approval of closure plans for industrial hazardous waste disposal units and the design of groundwater monitoring systems. Mr. Messenger served on the EPA/ASTSWMO Task Force to develop siting standards for hazardous waste landfills. He also acted as an expert witness in permit hearings, as a public speaker on behalf of the TDWR at various citizen, public and government meetings, and provided comments on behalf of the State of Texas on EPA regulations and guidance pertaining to hazardous waste management and implementation of HSWA requirements including Continuing Releases and Minimum Technological Requirements.

While at Hays & Lindsey, representative projects include industrial wastewater treatability studies/treatment plant designs as well as the design of microcomputer-based software for the performance evaluation, reporting and operation of a complex industrial wastewater treatment system.

While at Texas A&M University research projects include: investigation of the water quality of seven coastal canal communities in the Galveston Bay system during which conducting extensive sampling and chemical analysis of both canal water and runoff water as well as similitude and mathmatical modeling of stratification, circulation, and flushing in the canals was conducted to assess the causes of fish kills; the potential use of biological treatment processes for potable waste supplies were investigated using the Limulus Lysate and Standard Rabbit tests to quantify endotoxin concentrations and the effects of dermal, oral and inhalation exposure to treated wastewaters; and development of analytical procedures for the Ampule Method of COD determination on behalf of Oceanography International Corp. which included "Alternate Method Equivalency Testing". Mr. Messenger’s work resulted in EPA and ASTM approval of the Ampule Method as a replacement to the Standard Method COD (reflux) test.

While Assistant Director of Air and Water Pollution Control for the City of Nacogdoches, responsibilities included the sampling and analysis of local stream water quality, sampling and analysis of industrial wastewater discharges and effluent from the Citys' wastewater treatment facilities as well as operation of extended-air and two-stage trickling filter treatment plants.

ATTACHMENT B

Contentions Adopted By **Allen L. Messenger** In Accordance With Affidavit
NEV-SAFETY-5
NEV-SAFETY-130
NEV-SAFETY-135
NEV-SAFETY-137
NEV-SAFETY-138
NEV-SAFETY-168

Attachment 6

Affidavit of Adrian P. Butler

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF ADRIAN P. BUTLER

I, Adrian P. Butler, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Adrian P. Butler, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

A.P. Butler

Adrian P. Butler

The above-named affiant personally appeared before me this 15th day of December, 2008, and executed this affidavit.

Pawel K. Salinger

Notary Public

My Commission expires: with life

PAWEL K. SALINGER
NOTARY PUBLIC
15 KENSINGTON HIGH STREET
LONDON W8 5NP
ENGLAND

ATTACHMENT A

CURRICULUM VITAE

ADRIAN P. BUTLER

Curriculum Vitae
DR ADRIAN BUTLER

Name:	Adrian Paul Butler
Date of birth:	13 July 1960
Nationality:	British
Present Appointment:	Reader in Subsurface Hydrology and Senior Tutor Department of Civil & Environmental Engineering, Imperial College London

Degrees:

B.Sc.	(1st Class Honours) Physics University of London (Imperial College)	1981
M.Sc.	Engineering Hydrology University of London (Imperial College)	1985
Ph.D.	Groundwater Hydrology University of London (Imperial College)	1993

Appointments:

Reader in Subsurface Hydrology Imperial College of Science, Technology & Medicine	2005
Senior lecturer Imperial College of Science, Technology & Medicine	2000
Lecturer Imperial College of Science, Technology & Medicine	1992
Research Assistant Imperial College of Science, Technology & Medicine	1988
Scientific/Higher Scientific Officer Meteorological Office, Bracknell	1981 – 1984

Memberships of learned societies:

Member, Royal Meteorological Society	1984
Member, British Hydrological Society	1988
Member, American Geophysical Union	2004
Member, Soil Science Society of America	2004

Teaching:

Lecturer to Engineering Hydrology MSc/DIC Course

Lecturer to Environmental Engineering MSc/DIC Course

Lecturer to Environmental Technology MSc/DIC Course

Lecturer to Environmental Diagnosis MSc/DIC Course

Lecturer to Civil Engineering and Civil and Environmental Engineering, MEng

Recent research grants and contracts:

	Radionuclide transport in vegetated soils UK Nirex/NDA/ANDRA, £3.5 million	1988-2007
	Lowland Catchment Research (LOCAR): Investigation of groundwater flow heterogeneity in chalk aquifers using detailed borehole arrays and stochastic modelling techniques, NERC £290k Hydrogeochemical functioning of lowland permeable catchments: from process understanding to environmental management, NERC/Environment Agency, £500k	2002-2006
	Decision support tool for innovative in-situ multi-contaminant groundwater remediation, DTI, £232k	2006-2009
	Modelling groundwater flood risk from extreme events NERC FREE thematic programme, approx £250k	2007-2010
Research training:	16 PhD students, 50 MSc students (approx)	1993 – date
College administration:	Senior Tutor, Department of Civil and Environmental Engineering	2003 – date

Professional and consultancy activities:

	Consultant British Nuclear Fuels Limited: Development of an experimental and modelling programme to investigate the hydrology at the low-level nuclear waste site, Drigg, Cumbria	1992 – 2000
	Committee member British Hydrological Society (BHS) South East Section	1995 – 2005
	Chairman of the local organising committee of BHS2004: International Conference in Hydrology (July 2004)	2003 – 2004
	National committee member British Hydrological Society	1995 – 2003
	Member of expect elicitation panel for the Food Standards Agency on modelling soil-plant transfer of radionuclides	2001
	Scientific Advisory Committee for ModelCARE 2005	2003 – 2005
	Consultant to Expedition Engineering: Development of Kempton Park racecourse	2004 – 2005

	Technical Expert for the State of Nevada: Review of DOE safety case of radioactive waste repository at Yucca Mountain	2004 –
	Consultant to Quintessa: Preliminary Safety Analysis Report for the Low-Level Radioactive Waste Repository Baita Bihor, Romania.	2005 – 2006
	Member of DEFRA review group on Sources and Impacts of Past, Current and Future Contamination of Soil	2005 – 2006
	UK Groundwater Modelling Forum Committee Member	2005 –
	Editorial Board Quarterly Journal of Engineering Geology and Hydrogeology, Geological Society	2008 –
	Expert witness for Environment Agency prosecution case against Magnox Limited.	2008 –

Research expertise:

Published research is primarily associated with work on measuring, analysing and modelling subsurface flow and transport processes and their associated environmental impact. Particular areas within this context are:

i) Migration of radionuclides through soil and uptake by vegetation
ii) Application of stochastic contaminant transport modelling to groundwater protection
iii) Development of new modelling techniques for environmental risk assessment
iv) Development of analytical/modelling tools for flow and transport in fractured rock

Major contributions include:

- development of physically-based models of soil-to-plant transfer of radionuclides, which have provided the basis for new developments in safety assessment models for radioactive waste disposal;

- use of stochastic modelling techniques to represent the effects of uncertainty, arising from spatial heterogeneity, in groundwater protection;

- development of new techniques for modelling landfill biodegradation processes and their environmental impact;

- development of new methods for investigating and modelling flow and transport in permeable (fractured) catchments, in particular the Chalk of southern and eastern England.

Publications:

Refereed Journals

Mathias, S.A., Butler, A.P., Atkinson, T.C., Kachi, S., and Ward, R.S. A parameter sensitivity analysis of two chalk tracer tests, Quart. Journ. Eng. Geol. and Hydrogeol. *(In Press)*.

Ireson, A.M., Mathias, S.A., Wheater, H.S. and Butler, A.P. A model for flow in the Chalk unsaturated zone incorporating progressive weathering, J. Hydrology (*In Press*).

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Jackson, B.M., Wheater, H.S., Wade, A.J., Butterfield, D., Mathias, S.A., Ireson, A.M., Butler, A.P., McIntyre, N.R. and Whitehead, P.G., Catchment-scale modelling of flow and nutrient transport in the Chalk unsaturated zone, Ecol. Model. (2007),209, 41-52, doi:10.1016/j.ecolmodel.2007.07.005.

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Mathias, S. A., Butler, A.P., Peach, D.W. and Williams, A.T., Recovering tracer test input functions from fluid electrical conductivity logging in fractured porous rocks, Water Resour. Res., (2007), 43, W07443, doi:10.1029/2006WR005455.

Mathias, S. A., and Butler, A.P., Shape factors for constant-head double-packer permeameters, Water Resour. Res, (2007), 43, W06430, doi:10.1029/2006WR005279.

Mathias, S. A., Butler, A. P., Atkinson, T. C., Kachi, S., and Ward, R. S., A parameter identifiability study of two chalk tracer tests. Hydrol. Earth Syst. Sci. Discuss., (2006), 3, 1–35.

Mathias, S. A. and Butler, A. P., An improvement on Hvorslev's shape factors, Géotechnique, (2006), 56(10), 705–706.

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Ireson, A.M., Wheater, H.S., Butler, A.P., Mathias, S.A., Finch, J. and Cooper, J.D., Hydrological processes in the Chalk unsaturated zone – Insights from an intensive field monitoring programme, J. Hydrology (2006) 330, 29–43, doi:10.1016/j.jhydrol.2006.04. 021.

Williams, A., Bloomfield, J., Griffiths, K. and Butler, A.P., Characterising the vertical variations in hydraulic conductivity within the Chalk aquifer, Journal of Hydrology (2006) 330, 53–62, doi:10.1016/j.jhydrol. 2006.04.036

Jackson, B.M. Wheater, H.S., Mathias, S.A., McIntyre, N. and Butler, A.P., A simple model of variable residence time flow and nutrient transport in the chalk, Journal of Hydrology (2006) 330, 221– 234, doi:10.1016/j.jhydrol.2006.04.045.

Mathias, S. A., and Butler, A. P., Linearized Richards' equation approach to pumping test analysis in compressible aquifers, Water Resour. Res., (2006), 42, W06408, doi: 10.1029/2005WR004680.

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Bakr, M.I. and Butler, A.P., Worth of head data in well capture zone design; deterministic and stochastic analysis. J. Hydrology, (2004), 290, 202-216.

Zacharof, A.I. and Butler, A.P., Stochastic modelling of landfill leachate and biogas production incorporating waste heterogeneity: Model Formulation and Uncertainty Analysis, Waste Management, (2004), 24, 453-462.

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Wheater, H.S., Onof, C., Butler, A.P. and Hamilton, G.S., A multivariate spatial-temporal model of rainfall in south-west Saudi Arabia: II Regional analysis and long-term performance, J. Hydrology, (1991), 125, 201-220.

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Mathias, S.A., Butler, A.P., McIntyre, N. and Wheater, H., Applicability of box models to dual porosity systems, Hydrology: Science and Practice for 21st Century (Vol I), (2004), 315-321.

Howden, N.J.K., Wheater, H.S., Peach, D.W. & Butler, A.P., Hydrogeological controls on surface/groundwater interactions in a lowland catchment, Hydrology: Science and Practice for 21st Century (Vol II), (2004), 113-122.

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Zacharof, A.I. and Butler, A.P., Application of a stochastic leachate and biogas model to the Brogborough test cell experimental data incorporating data uncertainty, Christensen, T.H., Cossu, R., Stegmann, R. ed. (CISA, Italy), 2001, I 119-128, (Proc. 8th Int. Waste Management and Landfill Symp., 2001).

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Published Peer Reviewed Reports

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Ashworth, D., Butler, A.P., Ciciani,L L. and Shaw, G. (2005). Analysis and Modelling of ^{75}Se Migration and Uptake in Vegetated Soils (Phase VIII experiment). Imperial College Report NRP_013.

Ashworth, D., Butler, A.P., Ciciani,L L. and Shaw, G. (2005). Radiochemical Analysis and Modelling of the Phase VII Soil Column Experiment. Imperial College Report NRP_012.

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Butler A. P., Wadey, P., Shaw, G., Ciciani L., (2001). Radiochemical Analysis and Modelling of the Phase IV Soil Column. Imperial College Report NRP_003.

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ATTACHMENT B

Contentions Adopted By **Adrian P. Butler** In Accordance With Affidavit
NEV-SAFETY-20
NEV-SAFETY-22
NEV-SAFETY-23
NEV-SAFETY-27
NEV-SAFETY-31
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NEV-SAFETY-66

Attachment 7

Affidavit of Robert J. Halstead

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
	)	
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF ROBERT J. HALSTEAD

I, Robert J. Halstead, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Robert J. Halstead, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Robert J. Halstead
Robert J. Halstead

The above-named affiant personally appeared before me this 11th day of December, 2008, and executed this affidavit.

AMANDA STAHL
NOTARY PUBLIC
STATE OF WISCONSIN

Amanda Stahl
Notary Public

My Commission expires: 6/17/12

ATTACHMENT A

CURRICULUM VITAE

ROBERT J. HALSTEAD

STATEMENT OF QUALIFICATIONS
NUCLEAR WASTE TRANSPORTATION PLANNING

ROBERT J. HALSTEAD
P.O. BOX 60
PORTAGE, WI 53901-0060
PHONE: (608) 742-3973

1. Academic Background

BA, with High Honors, American Studies-Political Science Concentration, University of Delaware, 1970. Governor's Summer Fellow in Public Policy, urban planning internship with Model Cities Program, Wilmington, DE, 1969. Also worked as civil engineering drafter, New Castle County Public Works Department, and as conservation officer, Delaware Department of Natural Resources, while attending University of Delaware.

MA, American History, University of Wisconsin-Madison, 1972. Coursework concentration in Political and Diplomatic History.

Completed all course work for Ph.D. in American History, University of Wisconsin-Madison, 1974. Minor fields: Industrial Relations and Latin American Economic History. Language Proficiency: German and Spanish. National Defense Education Act Fellow, 1971-74. Extensive graduate research on 20th Century Energy and Environmental Policy. Dissertation research on origins of American dependency on imported oil, and environmental, social, and economic impacts of American oil operations in Mexico, 1900-1930.

Visiting Lecturer, American Labor History, University of Wisconsin-Madison, 1974-75.
Instructor, American Economic History, University of Massachusetts-Boston, 1975-77.
Taught introductory courses in American History from Colonial Period to Present. Taught advanced courses in Social and Economic History, focusing on social and environmental impacts of technological changes in transportation and manufacturing.

Served as education advisor to the Professional Drivers' Council and other rank-and-file caucuses within the International Brotherhood of Teamsters and other labor unions, 1975-78. Lectured at national labor conferences on history of Federal transportation policy, development of the interstate highway system and the long-distance trucking industry, and unionism in the railroad and trucking industries.

2. Experience with Spent Nuclear Fuel and High-Level Nuclear Waste Transportation Planning, Impact Assessment, Risks and Related Issues

More than 30 years of experience with spent fuel and nuclear waste transportation planning and impact assessment at the national, state, and local levels. List of reports, publications, and major presentations attached.

Energy Facilities Analyst, Division of State Energy, Wisconsin Department of Administration, Madison, 1978-1983. Evaluated electric utility advance plans for generation and transmission. Analyzed impacts of existing and proposed power plants, and represented agency in proceedings before the Public Service Commission of Wisconsin. Lead technical and policy analyst on high-level nuclear waste transportation issues for state agency designated by Governor to represent State in dealings with U.S. Department of Energy, other federal agencies, and electric utilities. Issues included spent nuclear fuel shipments from, and return shipments to, three commercial nuclear power stations in Wisconsin; through-shipments of commercial and naval spent nuclear fuel; and potential shipments of spent fuel and high-level waste to geologic repository candidate sites in Wisconsin, Minnesota, and Michigan. Also prepared technical and policy analyses regarding transportation of low-level radioactive wastes, coal, coal slurry, coal combustion wastes, and liquid petroleum fuels.

Nuclear Policy Analyst, Radioactive Waste Review Board, Wisconsin Department of Administration, Madison, 1983-1988. Senior policy analyst on high-level nuclear waste transportation issues for appointed board created by the Legislature to represent State in dealings with U.S. Department of Energy, other federal agencies, and electric utilities. Issues included spent nuclear fuel shipments from, and return shipments to, three commercial nuclear power stations in Wisconsin; through-shipments of commercial and naval spent nuclear fuel; and potential shipments of spent fuel and high-level waste to geologic repository candidate sites in Wisconsin, Minnesota, and Michigan. Lead technical reviewer for nuclear waste system analysis, transportation, and socioeconomic impacts. Coordinated major document reviews by interagency technical teams.

Consultant, Social and Economic Impacts of Nuclear Waste Transportation and Disposal, Texas Advisory Commission on Intergovernmental Relations, 1987. Prepared written analysis of socioeconomic impacts associated with transportation of spent nuclear fuel to, and disposal in, a geologic repository site in Deaf Smith County, Texas.

Consultant, Nuclear Waste Storage and Transportation, Minnesota Environmental Quality Board, 1989-1990. Prepared written analyses of the risks and impacts associated with storage and transportation of spent nuclear fuel at the Prairie Island Nuclear Power Station.

Consultant, Nuclear Waste Storage and Transportation, Land and Water Fund (LAW) of the Rockies, Boulder, CO, 1997-1998. Prepared written analyses of the risks and impacts associated with storage and transportation of spent nuclear fuel at the proposed Private Fuel Services (PFS) Storage Facility, Skull Valley Goshute Indian Reservation, Toele County, Utah. Reviewed PFS license application and environmental report submitted to U.S. Nuclear Regulatory Commission (NRC) pursuant to 10CFR72. Provided technical and policy advice to LAW legal counsel during NRC Pre-Licensing Conference.

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Transportation Advisor, Nuclear Waste Project Office (NWPO), State of Nevada, Agency for Nuclear Projects, Carson City, 1988-Present. Advise NWPO on a broad range of high-level nuclear waste transportation issues. Review federal and state nuclear waste transportation program documents, technical reports, and regulations. Manage contractor studies on nuclear waste transportation systems planning, risk assessment, regulations, shipping cask design, accident prevention, and emergency management. Represent NWPO positions on transportation issues at national meetings and conferences, meetings of regional organizations such as the Western Interstate Energy Board (WIEB) and the Western Governors' Association (WGA), and meetings in Nevada with state agencies, local governments, Indian tribes, and the general public.

3. Knowledge of the Federal High-Level Nuclear Waste Disposal Program and its Transportation Aspects/Requirements

Thorough knowledge, based on 30 years experience, of all major aspects of the Federal high-level nuclear waste management program, especially the transportation aspects and requirements relative to the proposed repository candidate site at Yucca Mountain, Nevada.

Department of Energy (DOE) Application to Nuclear Regulatory Commission (NRC) for License to Construct a Geologic Repository at Yucca Mountain. Reviewed transportation-related portions of the license application, including the Safety Analysis Report (SAR) and supporting documents submitted to NRC, 2008. Prepared transportation-related licensing contentions to be submitted to NRC by Nevada legal team.

DOE Application to Surface Transportation Board (STB) for Certificate of Public Convenience and Necessity (CPCN) for the Caliente Rail Line. Reviewed, and prepared extensive analysis of, DOE application to STB for CPCN for Caliente Rail Line, 2008. Prepared written comments submitted to STB on behalf of State of Nevada. Prepared presentations on Caliente Rail Line issues for major meetings and conferences, and formal statement for STB public hearing on DOE application.

Final Supplemental Environmental Impact Statement (FSEIS) for Yucca Mountain. Reviewed and prepared analyses of all transportation-related portions of DOE 2008 FSEIS (Summary, Chapters 3 and 6, and Appendices A and J). Directed subcontractor research on consequences of terrorist incidents, and impacts of proposed and alternative shipping routes. Advised State legal team on potential issues for NEPA lawsuit.

DOE Studies of Potential Nevada Rail Corridors to Yucca Mountain. Reviewed, and prepared extensive analyses of, all major DOE studies of potential corridors for construction of a new rail line to Yucca Mountain, 1990-2008. Directed subcontractor studies of rail construction and operations impacts. Personally traveled more than 90% of the total length of potential rail corridors identified in the FEIS, prepared extensive photographic documentation, attended local meetings, and interviewed affected stakeholders. Directed subcontractor studies of the Caliente and Mina corridors, and prepared review comment on Draft EIS, October 2007, and Final EIS, June 2008.

Draft Supplemental Environmental Impact Statement (DSEIS) for Yucca Mountain. Prepared extensive analyses of all transportation-related portions of the DOE 2007 DSEIS (Summary, Chapters 3 and 6, and Appendices G and H). Prepared and delivered preliminary comments at four DOE public hearings during 2007. Directed subcontractor research on consequences of severe accidents and terrorist incidents, and alternative transport modes and shipping routes. Prepared final comments on transportation submitted to DOE, 2007.

Final Environmental Impact Statement (FEIS) for Yucca Mountain. Prepared extensive analyses of all transportation-related portions of the U.S. Department of Energy (DOE) 2002 FEIS (Summary, Chapters 3 and 6, and Appendices A and J). Prepared and delivered testimony before U.S. House and Senate subcommittees during 2002.Directed subcontractor research on consequences of severe accidents and terrorist incidents. Evaluated DOE rail access construction and operations studies. Advised State legal team on NEPA lawsuit.

Draft Environmental Impact Statement (DEIS) for Yucca Mountain. As transportation advisor to State of Nevada Agency for Nuclear Projects, coordinated review of all transportation-related portions of the U.S. Department of Energy (DOE) 1999 DEIS (Summary, Chapters 3 and 6, and Appendices A and J). Prepared and delivered preliminary comments at eight DOE public hearings during 1999 and 2000. Directed subcontractor research on consequences of severe accidents and terrorist incidents, rail access construction and operation, heavy haul truck transport of large rail casks, and alternative transport modes and shipping routes. Prepared final comments on transportation submitted to DOE, 1999-2000.

State of Nevada Yucca Mountain Impact Report. As transportation advisor to State of Nevada Agency for Nuclear Projects, developed comprehensive plan for all transportation-related portions of the forthcoming State of Nevada Yucca Mountain Impact Report. Identified critical gaps in previous transportation impact studies, and developed and directed subcontractor research in the following areas: human health and economic consequences of severe transportation accidents resulting in release of radioactive materials at specific locations along rail and highway routes in urban and rural Nevada communities; human health and economic consequences of severe accidents at specific locations along rail routes to Nevada; potential radiation exposures from routine (incident-free) transportation at specific locations along Nevada rail and highway routes to Yucca Mountain; overall reexamination of transportation routine radiation exposures and resulting human health consequences; and supplemental analysis of rail access and heavy haul truck construction and operations impacts in Nevada, 2000-2001.

Federal Legislation. As policy advisor to the State of Wisconsin and to the Wisconsin congressional delegation, and as a member of National Governors' Association advisory groups, participated in development of the legislation which resulted in enactment of the Nuclear Waste Policy Act(NWPA) of 1982, and the Nuclear Waste Policy Amendments Act(NWPAA) of 1987. As advisor to the State of Nevada, reviewed and analyzed proposed legislation to further amend the Federal high-level radioactive waste management program, 1988-2008.

Federal Program Documents. Reviewed and analyzed most major program documents published by U.S. DOE since 1978, including the following:
Interagency Review Group Report, 1978
Generic Environmental Impact Statement, 1980
Siting Guidelines, 1983
AMFM Panel Report, 1984

Defense Waste Commingling Report, 1985
Mission Plan, 1985
Crystalline Repository Project Draft Area Recommendation Report, 1986
Repository Candidate Site Environmental Assessments, 1986
Oak Ridge Monitored Retrievable Storage Facility Environmental Assessment, 1986
MRS Review Commission Report, 1987
Mission Plan Amendment, 1988
Section 175 Report, 1988
Nuclear Waste Fund Fee Adequacy Assessment, 1990
Mission Plan Amendment, 1991
Civilian Radioactive Waste Management Program Plan, 1994
Multi-Purpose Canister System Evaluation, 1994
EIS for the Nevada Test Site and Off-Site Locations, 1996
Civilian Radioactive Waste Management Program Plan, Revision 1, 1996
US Navy EIS for Management of Naval Spent Nuclear Fuel, 1996
Summary of Public Scoping Comments (Yucca Mountain EIS), 1997
NTS Intermodal Transportation Facility Study, 1998
Civilian Radioactive Waste Management Program Plan, Revision 2, 1998
DOE Draft Statement of Work for a Transportation Integration Contractor, 2002
DOE TEC Draft Paper on Rail Routing, 2003
BLM Notice of Proposed Land Withdrawal for the Caliente Rail Corridor, 2004
DOE Notice of Intent to Prepare an EIS for a Rail Line to Yucca Mountain, 2004
DOE Draft EIS for Withdrawal of Public Lands for the Proposed Caliente Rail Corridor, 2005
DOE Draft EA for Proposed Infrastructure Improvements for the Yucca Mountain Project, 2006
DOE Amended Notice of Intent to Prepare an EIS for a Rail Line to Yucca Mountain, 2006
DOE Notice of Intent to Prepare a Supplement to the Final EIS for Yucca Mountain, 2006
DOE Transportation Concept of Operations Report, 2007
DOE Draft National Transportation Plan, 2007
DOE Technical Specifications for the Proposed Transportation, Aging, and Disposal (TAD) Canister System, 2007.
DOE Proposed Policy Position on Section 180c Implementation, 2007
DOE TEC White Paper on Intermodal Transportation of Commercial Spent Nuclear Fuel, 2008

Waste Program Transportation Aspects and Requirements. Attended virtually all major U.S. DOE nuclear waste transportation program meetings, technical conferences, and workshops since 1982. Prepared numerous reports and presentations on the following aspects of the U.S. DOE nuclear waste transportation program:

- Transportation systems planning, logistics, and economics
- Risk and impact assessment, including impacts of constructing rail access
- Federal and state regulations
- Shipment routing
- Shipping cask design and testing
- Accident prevention, including human factors considerations
- Physical protection and safeguards

- Emergency management
- Stakeholder information needs
- Privatization of transportation services.

4. Experience in the Review and Development of Regulations and Legislation Relative to the Safe Transportation of Radioactive Materials

Overall, 30 years experience in the review and development of regulations and legislation relative to the safe transportation of radioactive materials.

Prepared detailed written analyses of the transportation implications of all major congressional legislation related to establishment of a federal high level nuclear waste management program, including legislation which resulted in enactment of the Nuclear Waste Policy Act (NWPA) of 1982, 1978-1983.

Prepared detailed written analyses of the draft and final transportation provisions of the Repository Siting Guidelines promulgated by USDOE, 1983-1984.

Prepared detailed written analyses of terrorism and sabotage issues, and formal comments on the modification of spent fuel transportation safeguards regulations proposed by USNRC, 1984.

Assisted Wisconsin Department of Natural Resources in modification of hazardous materials spill prevention planning regulations to apply to spent nuclear fuel shipments, 1984-1986.

Assisted Wisconsin Department of Justice in analysis of federal preemption of state and local transportation regulations, 1984-1986.

Assisted Wisconsin congressional delegation staff in development of legislation to establish USDOT rail routing guidelines and to require preparation of route-specific environmental impact statements by USNRC for major spent fuel shipping campaigns, 1984-1987.

Assisted Wisconsin and Nevada congressional delegation staff in development of transportation amendments, including a requirement for full-scale cask testing, to congressional legislation resulting in enactment of the Nuclear Waste Policy Amendments Act (NWPAA) of 1987, 1985-87.

Prepared detailed written analyses of transportation implications of the NWPAA, including Section 180(C) Assistance To Corridor States and Indian Tribes, 1987-1988.

Prepared detailed written analyses of transportation implications of the Price Anderson Act Amendments, 1988.

Prepared a comprehensive review of current federal, state, local, and Indian tribe transportation regulations as part of the ACR 8 Report mandated by The Nevada Legislature, 1988.

Assisted Nevada Congressional delegation staff in development of amendments to the Hazardous Materials Transportation Act to require full-scale cask testing, use of dedicated trains, and rail routing guidelines, 1988-1990.

Reviewed and analyzed nuclear waste transportation provisions of The Hazardous Materials Transportation Uniform Safety Act (HMTUSA), and participated in USDOT workshops and conferences implementing HMTUSA required studies of mode and route selection and use of dedicated trains, 1990-1993.

Participated in development of a comprehensive safety program for transuranic waste transportation to the Waste Isolation Pilot Plant (WIPP) as mandated by Congress USDOT and USDOE appropriations laws and by the WIPP Land Withdrawal Act, 1990-1996.

Assisted in development of proposals to implement Section 180(c) of NWPAA through USDOE rulemaking, 1990-1998.

Reviewed and analyzed model code developed by National Congress of American Indians for tribal regulation of hazardous materials storage and transportation, 1995.

Reviewed and analyzed State of Nebraska proposed nuclear waste transportation accident liability legislation, and testified before Nebraska Legislative Study Committee, 1995.

Monitored congressional deliberations, and prepared detailed written analyses of national, regional, and local transportation implications of congressional legislation to establish an interim storage facility at the Nevada Test Site and an intermodal transfer facility at Caliente, Nevada (H.R.1020,S.1271, S.1936), 1995-1996.

Reviewed and analyzed State of California nuclear waste transportation safety legislation (AB2192), including provisions requiring full-scale physical testing of spent nuclear fuel shipping casks, and testified before the Transportation Committees, California State Assembly and Senate, 1997-1999.

Monitored congressional deliberations, and prepared detailed written analyses of national, regional, and local transportation implications of congressional legislation to establish an interim storage facility at the Nevada Test Site and an intermodal transfer facility at Caliente, Nevada (H.R.1270, S.104, S.1287), 1997-2000.

Conducted detailed review and analysis of terrorism and sabotage issues relative to USNRC nuclear waste transportation safeguards regulations(10CFR73), prepared draft and final petition for rulemaking seeking USNRC reassessment of terrorism risks and modification of spent fuel transportation safeguards regulations, and monitored NRC action on the petition, 1997-2001.

Prepared testimony on proposed State of Nevada legislation, SJR No.4, to evaluate alternative highway and rail routes to Yucca Mountain, 2001.

Conducted detailed review and analysis of shipping cask performance in severe accidents relative to U.S. Nuclear Regulatory Commission regulations (10CFR71). Developed and implemented strategy for Nevada participation in the NRC update of the Modal Study, later designated as the Package Performance Study (PPS). Represented Nevada at PPS public meetings, and prepared Nevada comments on NRC staff and contractor proposals for full-scale physical testing of spent fuel shipping casks. Monitored Commission discussions of, and action on, NRC staff proposals for future full-scale cask testing program, 1999-2006. Prepared detailed analyses of NRC documents.

Conducted detailed review and analysis of transportation provisions of various "fix Yucca Mountain" proposed congressional legislation, especially provisions regarding Federal preemption of State and tribal regulations, 2006-2007.

Conducted detailed review and analysis of rail routing regulations proposed by Departments of Homeland Security and Transportation for spent fuel shipments, 2007-2008.

5. Ability and Experience in Working with State and Local Officials with Regard to Transportation Activities and in Communicating with Diverse Publics on Transportation Issues

Overall, 30 years experience working with state and local officials and Indian tribes with regard to transportation activities, and communication with diverse publics on Transportation issues.

Served as Ombudsperson for energy-impacted coastal communities in Wisconsin; assisted local governments, counties, and regional planning commissions in assessing and mitigating risks and impacts of energy and transportation facilities and activities, including spent nuclear fuel storage and transportation activities and large coal transportation facilities; assisted local officials in developing site-specific mitigation and compensation measures; prepared handbook to assist stakeholders participation in siting and licensing proceedings, 1978-1983.

Provided information, policy advice, and technical assistance to Wisconsin Governors' Office, Legislature, Radioactive Waste Review Board, State agencies, local governments, Indian tribes, and general public on all aspects of nuclear waste transportation through briefings, written reports, presentations at public meetings, and telephone and written response to information requests, 1978-1988.

Provided information, policy advice, and technical assistance to Nevada Governors' Office, Legislature, Commission on Nuclear Projects, State agencies, local governments, Indian tribes, and general public on all aspects of nuclear waste transportation through briefings, written reports, presentations at public meetings, and telephone and written response to information requests, 1988-2008.

Worked cooperatively with a broad range of state government policy makers and state agency technical personnel on task forces, advisory committees, and working groups, including

- State of Wisconsin Technical Advisory Council on High-Level Radioactive Waste, 1980-1988 (Vice-Chair, 1982-1986)
- National Governors' Association Task Force on High-Level Nuclear Waste Management, 1980-1985
- State of Tennessee Technical Advisory Panel On Nuclear Waste, 1986
- State of Nevada State, Local, Tribal Government Coordinating Group, 1988-1994
- Western Governors Association WIPP Transportation Technical Advisory Group, 1990-2000 (Co-Chair, 1990-1995)
- Western Interstate Energy Board High-Level Radioactive Waste Committee, 1988-2007 (Co-Chair, 1990-1995)

Through presentations on a broad range of nuclear waste transportation policy and technical issues from 1980-2008 demonstrated ability to communicate with diverse publics at

- USDOE Transportation Coordination Group Meetings (National)
- USDOE Transportation External Coordination (TEC) Working Group Meetings (National)
- USDOE Yucca Mountain EIS Scoping Meetings (National)
- USDOE-Sponsored National/International Technical Conferences (Waste Management, PATRAM, IHLRWM)
- Legislative Committee Hearings (California, Nebraska, Wisconsin)
- American Nuclear Society Topical Meetings (National)
- National Congress of American Indians, National Indian Nuclear Waste Policy Committee Meetings (National)
- Meetings sponsored by public interest groups such as League of Women Voters, Sierra Club, and Environmental Policy Center (National, Regional and Local)
- USDOE Yucca Mountain Project Public Meetings (Nevada)
- NWPO Public Information Meetings (Nevada)
- Legislative Committee Hearings and Meetings (Nevada)
- Intertribal Council of Nevada Meetings (Nevada)
- County-sponsored Public Information Meetings (Clark, Elko, Eureka, Lander, Lincoln, Mineral, Nye, Washoe, and White Pine Counties, Nevada)
- University -sponsored Lectures (Nevada)
- Training Seminars for Emergency Responders (Nevada)

6. Ability to Work with and Provide Liaison to the Broader Academic and Professional Community

Over past 30 years, have developed cordial and effective working relationships with many members of the nuclear waste management academic and professional community nationally and in Nevada.

Attended virtually all transportation meetings of the U.S. Nuclear Waste Technical Review Board and its constituent panels, 1989-2008. Presented State of Nevada's transportation concerns to the board through formal and informal presentations, and through discussion with individual board members and staff.

Attended all public meetings of the National Academy of Sciences (NAS) Study Committee on Transportation of Radioactive Waste, 2003-2005. Presented State of Nevada's concerns to the committee through formal and informal presentations, and through discussion with individual board members and staff. Prepared detailed analyses of the NAS final report, Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States (2006).

Attended a broad range of nuclear waste professional meetings and conferences and presented papers on and participated in panel discussions on a broad range of transportation issues, 1986-2008. For example:

- Presented papers on At Reactor Storage, Monitored Retrievable Storage, Geologic Disposal, Transportation Regulation, and Terrorism and Sabotage, at the annual international Waste Management Conference in Tucson, Arizona (!986-2008)
- Presented recommendations on Yucca Mountain transportation safety and security to major meetings of the American Nuclear Society and the Nuclear Energy Institute (2008)
- Presented papers on transportation shipping cask design and testing, institutional aspects of shipment routing, and the multipurpose canister storage/transportation system at the annual International High-Level Radioactive Waste Management Conferences in Las Vegas (1990, 1994, 1995)
- Presented paper on Terrorism and Sabotage Risks at the International Symposium on Packaging and Transportation of Radioactive Materials (PATRAM), Chicago, Il (2001)
- Represented State of Nevada in a Point-Counterpoint Debate regarding Nuclear Waste Transportation Safety and Security at the International Symposium on Packaging and Transportation of Radioactive Materials (PATRAM), Chicago, Il (2001)
- Represented State of Nevada at U.S. Nuclear Regulatory Commission Workshops on Transportation Risk Assessment and Transportation Package Performance in Accidents (1999-2006)
- Participated in panel discussions of transportation risk assessment and shipping cask design and testing at annual meetings of the National Transportation Research Board (1990, 1995) and the American Nuclear Society (1994, 1995)
- Assisted in the development of the Transportation Research Center at the University of Nevada, Las Vegas, including preparation of work plans and budgets, recruitment of research staff, establishment of technical library, data collection, and management of contractor studies, 1988-1995.
- Maintained cordial professional relationship with nuclear waste transportation researchers, and regularly monitored research activities at University of Nevada, Reno; Sandia National Laboratories, Idaho National Engineering Laboratories; Oak Ridge National Laboratories, and other institutions.

7. Understanding and Knowledge of Potential High-Level Waste Transportation Routes and Issues Specific to the State of Nevada

Thorough knowledge, based on 20 years experience, of potential high-level radioactive waste transportation routes and issues specific to the State of Nevada.

Reviewed and analyzed Nevada highway routing reports prepared by USDOE, NDOT, UNR, NWPO, UNLV-TRC, and Nevada counties; traveled and photographed all potential Nevada highway routes, at different times of year and during a variety of weather conditions; prepared detailed written analyses and slide presentations on Nevada highway routes, identifying high-risk locations and route segments; 1989-2008.

Reviewed and analyzed Nevada rail routing reports prepared by USDOE, UNR, UNLV-TRC, and Nevada counties; traveled and photographed approximately 90% of existing rail routes and potential new rail access routes which could be used for shipments to Yucca Mountain; prepared detailed written analyses and slide presentations on potential rail routes (existing and new), identifying high-risk locations and route segments, and areas where new construction might be constrained by economic, environmental, demographic, or conflicting land use considerations, 1989-2008.

Prepared detailed written analyses and slide presentations on transportation issues of particular concern to the State of Nevada, 1989-2008, including:

- Vulnerability of the Nevada tourism economy, especially the Las Vegas Valley to public perception of transportation risks
- Engineering feasibility, environmental, and safety considerations associated with rail (existing and new) and highway routes through river valleys and high mountain passes
- Transportation safety issues associated with military aircraft overflights and training operations
- Impacts on Native American lands and cultural resources
- Impacts on environmentally sensitive areas and threatened and endangered species
- Impacts on privately owned lands, and land use conflicts with grazing activities on BLM lands.

8. Familiarity with Western States Transportation Issues

Thorough familiarity, based on 20 years experience, with transportation issues of concern to Western States and regional organizations(Western Interstate Energy Board, Western Governors Association).

Attended virtually all meetings of the High-Level Radioactive Waste Committee, Western Interstate Energy Board, 1989-2008. Served as Co-Chair, 1990-1995.

Presented State of Nevada's concerns to the committee through participation in meetings, formal presentations, and through discussion with individual board members and staff. Provided ongoing technical assistance to WIEB staff.

Prepared detailed written analyses and presentations on, and assisted Western States and regional organizations, 1989-2008, in development of strategies regarding:

- Selection of safest shipment modes and routes
- Selection of safe carriers and drivers for truck shipments
- Use of dedicated trains for rail shipments
- Full-scale cask testing
- Safety inspections (mechanical and radiological)
- Bad weather protocols
- Safe parking areas
- Adequate and equitable funding for State accident prevention and emergency response programs, pursuant to Section 180(c), NWPAA.

PUBLICATIONS, PRESENTATIONS, & TESTIMONY

ROBERT J. HALSTEAD
P.O. BOX 60
PORTAGE, WI 53901-0060
PHONE: (608) 742-3973

PUBLICATIONS

"State of Nevada Perspective on the U.S. DOE Yucca Mountain Transportation Program" (Paper presented at Waste Management 2008, Phoenix, AZ, with F.C. Dilger & J.D. Ballard)

"Assessing the Vulnerability of Yucca Mountain Shipments: A Threat Matrix for Human-Initiated Events" (Paper presented at Waste Management 2008, Phoenix, AZ, with J.D. Ballard and F.C. Dilger)

"Yucca Mountain Transportation Security Issues: Overview and Update." (Proceedings, Waste Management 2007, Tucson, AZ, with J.D. Ballard and F.C. Dilger)

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"Radioactive Materials Transportation and Reauthorization of the Federal Hazardous Materials Transportation Act," Hazardous Materials/Nuclear Waste Transportation Emergency Response Seminar, Sparks, NV, Oct. 5, 1989

"The Challenges of Planning for Nuclear Waste Transportation Emergencies," Hazardous Materials/Nuclear Waste Transportation Emergency Response Seminar, Reno, NV, March 22, 1989

"Nuclear Waste Transportation Safety Issues," High Level Nuclear Waste Repository Education Forum, Las Vegas, NV, November 10, 1988

"Nuclear Waste Shipments in the Mississippi River Boundary Area," Minnesota-Wisconsin Boundary Area Commission, Red Wing, MN, November 13, 1986

"Nuclear Power and Nuclear Waste," John Muir Chapter of the Sierra Club Annual Meeting, Lake Geneva, WI, October 18, 1986

"A State Perspective on the U.S. Department of Energy's Crystalline Repository Project," North Central Regional Conference on High-Level Nuclear Waste, University of Wisconsin-Superior, Superior, WI, September 27, 1985

"Environmental Considerations in Route Designation for Rail Shipments," Colorado High Level Nuclear Waste Transportation Conference, Keystone, CO, October 12, 1984

"Implementation of the Nuclear Waste Policy Act of 1982," Environmental Policy Center Conference on Nuclear Waste Options for the Future, Washington, DC, December 10, 1983

"The Nuclear Waste Policy Act of 1982," Wisconsin Audubon Council Annual Meeting, Whitewater, WI, September 10, 1983

"Economic and Environmental Considerations in Coal Port Planning," Coal Port Study Committee, Washington Public Ports Association, Olympia, WA, June 3, 1982

"Environmental Impacts of Coal Transportation and Combustion," Marine Engineering Group Seminar, Public Works Canada, Toronto, Ontario, December 19, 1980

"Coastal Energy Impacts and Environmental Protection," Wisconsin League of Women Voters State Convention, Madison, WI, September 29, 1980

"Mitigating the Impacts of Coastal Energy Facilities," U.S. Department of Commerce Coastal Management Program Annual Meeting, East Sound, WA, July 14, 1980

"Energy Impacts in the Great Lakes Coastal Zone," U.S. Department of Commerce Coastal Energy Impact Program Annual Meeting, Washington, DC, April 23, 1980

TESTIMONY

On potential nuclear waste transportation risks and impacts in Las Vegas, before the Subcommittee on Railroads, U.S. House of Representatives Committee on Transportation and Infrastructure, Las Vegas, NV, March 5, 2004

On nuclear waste transportation impacts of the proposed Yucca Mountain repository, before the U.S. Senate Committee on Energy and Natural Resources, Washington, DC, May 22, 2002

On nuclear waste transportation impacts of the proposed Yucca Mountain repository, before the Subcommittees on Railroads and Transportation of Hazardous Materials, U.S. House of Representatives Committee on Transportation and Infrastructure, Washington, DC, April 25, 2002

On Senate Joint Resolution No. 4, Before the Nevada Legislature, Senate Committee on Transportation, Carson City, NV, March 22, 2001

On potential nuclear waste transportation impacts and risks in California, and full-scale physical testing of spent nuclear fuel shipping casks, before the Transportation Committee, California State Senate, Sacramento, CA, August 5, 1998

On potential nuclear waste transportation impacts and risks in California, and full-scale physical testing of spent nuclear fuel shipping casks, before the Transportation Committee, California State Assembly, Sacramento, CA, March 30, 1998

On the impacts of a proposed spent nuclear fuel interim storage facility in Lincoln County, Nevada, in the Seventh Judicial District Court of the State of Nevada, expert testimony on behalf of the State of Nevada, in the matter of State of Nevada vs. Lincoln County, April 10, 1995

On the status of the federal nuclear waste program and implications for electric utility advance planning, before the Public Service Commission of Wisconsin, Docket No. 05-EP-5, July 25, 1988

On the Nuclear Waste Policy Amendments Act of 1987; before the Subcommittee on Energy and Power, House Committee on Energy and Commerce, October 16, 1987

On the Nuclear Waste Policy Amendments Act of 1987; before the Subcommittee on Energy and Environment, House Committee on Interior and Insular Affairs, September 18, 1987

On the Department of Energy's Proposed Siting Guidelines for Nuclear Waste Repositories; before the U.S. Nuclear Regulatory Commission, January 11, 1984

On coal transportation impacts and coal supply alternatives for electric utilities; before the Public Service Commission of Wisconsin, Docket No. 05-EP-3, June 8, 1982

ATTACHMENT B

Contentions Adopted By **Robert J. Halstead** In Accordance With Affidavit
NEV-SAFETY-196
NEV-SAFETY-197
NEV-SAFETY-198
NEV-NEPA-01
NEV-NEPA-02
NEV-NEPA-03
NEV-NEPA-04
NEV-NEPA-05
NEV-NEPA-06
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NEV-NEPA-10
NEV-NEPA-11
NEV-NEPA-12
NEV-NEPA-13
NEV-NEPA-14
NEV-NEPA-15
NEV-NEPA-16
NEV-NEPA-22

Attachment 8

Affidavit of Brenda J. Little

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of)
)
U.S. DEPARTMENT OF ENERGY) Docket No. 63-001
)
License Application to Construct a)
Geologic Repository at Yucca Mountain)

AFFIDAVIT OF BRENDA J. LITTLE

I, Brenda J. Little, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Brenda J. Little, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Brenda J. Little
Brenda J. Little

The above-named affiant personally appeared before me this 15th day of December, 2008, and executed this affidavit.

Angelle Seals
Notary Public

My Commission expires:_______________

STATE OF MISSISSIPPI
NOTARY PUBLIC
ID # 84646
ANGELLE SEALS
Commission Expires
March 21, 2011
HANCOCK COUNTY

ATTACHMENT A

CURRICULUM VITAE

BRENDA J. LITTLE

Brenda J. Little

Home Address: 6528 Alakoko Drive
Diamondhead, MS
brenda.little@att.net
(228) 255-9353

Education: B.S. (Biology/Chemistry), Baylor University, Waco, TX, June 1967

Ph.D. (Chemistry), Tulane University, New Orleans, LA, December, 1983. Dissertation Title: Chemical Characterization of Adsorbed Dissolved Organic Material from an Estuarine Source.

Experience

8/96 - present	Senior Scientist for Marine Molecular Processes, Naval Research Laboratory, Stennis Detachment, Stennis Space Center, MS.
10/92 - 8/96	Supervisory Research Chemist, Naval Research Laboratory, Stennis Detachment, Stennis Space Center, MS.
11/86 - 10/92	Principal Investigator, Biological & Chemical Oceanography Branch, Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS.
11/85 - 11/86	Supervisory Oceanographer, Branch Head, Biological and Chemical Oceanography Branch, Naval Ocean Research and Development Activity, NSTL, MS.
10/76 - 11/85	Principal Investigator, Biological & Chemical Oceanography Branch, Naval Ocean Research and Development Activity, NSTL, MS.
4/74 - 10/76	Microbiologist, National Park Service Science Center, NSTL Station, MS.
11/72 - 4/74	Biochemist, General Electric Company, NSTL Station, MS.
3/71 - 11/72	Research Associate, Louisiana State University, Baton Rouge, LA.

Awards

3/08	2 NRL Alan Berman Research Publication Awards
3/05	NRL Alan Berman Research Publication Award
6/03	Meritorious Civilian Service Award
3/02	NRL Alan Berman Research Publication Award
6/01	Outstanding Performance Award

6/00	Outstanding Performance Award
6/00	Selected for 2000 Outstanding Women of the Twentieth Century
3/00	NRL Alan Berman Research Publication Award
6/99	Outstanding Performance Award
3/99	Technical Achievement Award National Association of Corrosion Engineers (NACE) – International
6/98	Outstanding Performance Award
3/98	Fellow Award NACE- International
6/96	Outstanding Performance Award
6/95	Outstanding Performance Award
3/95	Women in Science and Engineering Award for Scientific Achievement
8/94	Supervisor's Safety Award (7 years)
5/94	Outstanding Performance Award
3/94	Naval Research Laboratory Alan Berman Research Publication Award
7/93	Volunteer Recognition Award
6/93	Outstanding Performance Award
6/92	Outstanding Performance Award
11/91	Outstanding Performance Award
10/90	Outstanding Performance Award
2/90	Superior Achievement Award
12/89	Best NOARL Patent Award for 1989
11/89	Performance Management Recognition Service Award
1/89	Invention Award
12/88	Patent Awarded for Dual Cell Corrosion-Measuring Device
12/88	NORDA Publication Award
11/88	Performance Management Recognition Service Award
11/87	Performance Management Recognition Service Award
12/86	Performance Management Recognition Service Award
10/86	Selected for DOD Executive Leadership Program
3/86	Selected for American Men and Women in Science
2/86	Selected for Who's Who in Technology Today
12/85	Performance Management Recognition Service Award
12/83	Outstanding Performance Award
12/81	NORDA Publication Award Applied Research Paper
7/79	Selected for Long Term Training
7/76	Special Achievement Award

Professional Activities

Fellow, National Association for Corrosion Engineers (NACE)-International
Board of Directors, NACE-International
Assistant editor, *Biofouling*, The Journal of Bioadhesion and Biofilm Research
Chair of Awards Committee, NACE-International

Memberships

American Chemical Society, National Association of Corrosion Engineers, Sigma Xi, Mississippi Academy of Sciences.

Patent

Apparatus and Technique for Quantifying Microbiologically Influenced Corrosion Issued 1988

Books

B.J. Little and J. Lee (2007) Microbiologically Influenced Corrosion. John Wiley & Sons, Inc.

B.J. Little, P. Wagner and F. Mansfeld, 1997. Microbiologically Influenced Corrosion Testing, for Corrosion Testing Made Easy series, NACE International, Houston TX.

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J.C. Biffinger, J. Pietron, R. Ray, **B.J. Little** and B.R. Ringeisen (2007) A Biofilm Enhanced Miniature Microbial Fuel Cell using *Shewanella oneidensis* DSP10 and Oxygen Reduction Cathodes. Biosensors and Bioelectronics Vol.22 pp. 1672-1679.

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J. S. Lee, R.I. Ray, **B.J. Little,** E. Lemieux, and A. Falster (2004) An Evaluation Of Carbon Steel Corrosion Under Stagnant Sweater Conditions. Biofouling 20 (4-5) pp.237-247.

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.
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K.L. Lowe, W. Straube, **B.J. Little** and J. Jones-Meehan (2003) Aerobic and Anaerobic Reduction of Cr(VI) by *Shewanella oneidensis* Effects of Cationic Metals, Sorbing Agents and Mixed Microbial Cultures. Acta Biotechnologica 23:161-178.

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J.F. Banfield, J. W. Moreau, C.S. Chan, S.A. Welch and and **B.J. Little** (2001) Mineralogical Biosignatures and the Search for Life on Mars. Astrobiology 1(4) pp 447-467.

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B.J. Little, R. Ray and P. Wagner (1998) Tame Microbiologically Influenced Corrosion. Chemical Engineering Progress. September 1998; pp. 51-60.

J. S. Puh, P.A. Wagner, **B.J. Little** and W.L. Bradley (1998) The Effects of Biofouling on Graphite/Epoxy Composites. Journal of Composites Technology and Research,Vol. 20(1):pp. 59-67.

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I. Larsen, **B.J. Little**, K. Nealson, R. Ray, A. Stone and J. Tian (1998) Manganite Reduction by *Shewanella putrefaciens* MR-4, American Mineralogist83:1563-1568.

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R. Ray, **B.J. Little**, P. Wagner and K. Hart (1997) Environmental Scanning Electron Microscopy Investigations of Biodeterioration. Scanning 19(2): 98-103.

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ATTACHMENT B

Contentions Adopted By **Brenda J. Little** In Accordance With Affidavit
NEV-SAFETY-74
NEV-SAFETY-75
NEV-SAFETY-76

Attachment 9

Affidavit of Doug F. Hambley

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of U.S. DEPARTMENT OF ENERGY License Application to Construct a Geologic Repository at Yucca Mountain	)	Docket No. 63-001

AFFIDAVIT OF DOUGLAS F. HAMBLEY

I, Douglas F. Hambley, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Douglas F. Hambley, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Douglas F. Hambley

The above-named affiant personally appeared before me this 14th day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: 12-6-09

OFFICIAL SEAL
PAULETTE DYON
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:12/06/09

ATTACHMENT A

CURRICULUM VITAE

DOUG F. HAMBLEY

DOUGLAS F. HAMBLEY, Ph.D., P.E., P.Eng., P.G.
Mining Engineer and Geologist
Associate

Education

Ph.D.	(Earth Sciences) University of Waterloo, Ontario, Canada, 1991
M.B.A.	Lewis University, Romeoville, Illinois, 1986
B.Sc./Honours	(Mining Engineering) Queen's University at Kingston, Ontario, Canada, 1972

Professional Memberships

Registered Professional Engineer: States of Illinois (By examination), Maryland, Pennsylvania, Virginia, and Wisconsin, and Province of Ontario, Canada

Registered Professional Geologist: States of Illinois, Indiana (By examination), Pennsylvania and Wisconsin. Member, Illinois Board of Registration for Professional Geologists, 1996-2000

Member, Past (Founding) Chicago Section Chairman, Society for Mining, Metallurgy, and Exploration of AIME

Member, Canadian Institute of Mining, Metallurgy and Petroleum

Member, American Society of Mining and Reclamation

Member, Past Rock Mechanics Committee Chairman, Association of Engineering and Environmental Geologists

Member, National Ground Water Association

Experience

2007-Present	Associate, Agapito Associates, Inc., Lombard, Illinois. Dr. Hambley participates in projects related to mine and tunnel design, underground nuclear waste disposal, mine ventilation, blasting, and groundwater prediction. Recent projects have included review of the License Application for the Yucca Mountain Repository for the State of Nevada, design and cost development for new underground stone mines in Illinois and Ohio, ground control consulting to an industrial facility in a stone mine in Pennsylvania, evaluation of room and pillar stability at industrial mineral and limestone mines in Indiana, Illinois, Virginia, West Virginia and Wisconsin, and preparation of NI 43-101 technical reports for a uranium prospect in Arizona, potash deposits in Brazil and a sulfur deposit in Alberta.
2005-2007	Mining and Geo-Environmental Engineering Consultant, Wheaton, Illinois. Designed systems for remote backfilling mine voids in Oklahoma and Kentucky;
2000-2005	Senior Consultant, Practical Environmental Consultants, Inc., Schaumburg, Illinois. Consultant to Potawatomi Tribe on Crandon Mine in Wisconsin.
1992-2000	Senior Project Manager, Graef, Anhalt, Schloemer and Associates, Inc, Chicago, Illinois. Managed the Environmental Department in the Chicago Office. Program Manager on two successive three-year contracts with Illinois EPA as Statewide Consultant on State-Lead Brownfields investigations.
1991	Geo-Environmental Group Manager, Nova Environmental Services, Inc., Des Plaines, Illinois.

1989-1991	Special Term Appointee, Energy Systems Division, Argonne National Laboratory, Illinois. Reviewed references in documents developed by subcontractors on the Nevada Nuclear Waste Storage Isolation (NNWSI) project for accuracy for USDOE Office of Civilian Radioactive Waste Management (OCRWM); performed shielding calculations for proposed Hadron Injector tunnels at Fermilab for ANL High Energy Physics Division; Co-Principal Investigator on contract with Baltimore District, US Army Corps of Engineers for Technical Assistance on Superfund and Defense Environmental Restoration Project sites.
1989	Senior Consultant, Dunn Geoscience Corporation, West Chicago, Illinois. Performed reserve analysis for a stone quarry; blast vibration analysis for construction sites; due diligence for acquisition of salt mines in Louisiana and Canada.
1988	Research Assistant; Department of Earth Sciences, Univ. of Waterloo, Ont., Canada.
1984-1988	Mining Engineer, Energy & Environmental Systems Div., Argonne National Laboratory, Illinois. Responsible for mining engineering and facilities design on Peer Review of the Salt High-Level Nuclear Waste Program and served as Lead Reviewer on four of seven major document reviews conducted and reviewer of drafts of the Environmental Assessments for seven salt repository sites. Consultant to Fermilab on geology, tunneling and ventilation aspects of the Superconducting Supercollider (SSC) Accelerator.
1980-1984	Senior Mining Engineer, Engineers International, Inc., Westmont, Illinois. Project Engineer on USNRC contracts regarding retrievability of high-level nuclear waste and technical assistance for repository design reviews; Project Engineer for design and construction of tunnel and shaft for a hydroelectric project, and design of highway tunnels on I-70.
1977-1980	Long Range Planning Rock Mechanics Engineer, Denison Mines Ltd., Elliot Lake, Ontario. Responsible for ground control, pillar design, and special studies at the mine; performed ventilation studies for pillar mining in association with radioactive backfill placement.
1975-1976	Mining Engineer, Harrison Bradford and Associates, Ltd., St. Catharines, Ontario. Performed shaft and tunnel design studies for Strait of Belle Isle Cable Crossing in Newfoundland. Evaluated soft-ground tunnel bid specifications for Contractor.
1974-1975	Mining Engineer Trainee, Falconbridge Nickel Mines, Ltd., Falconbridge, Ontario. Long-range planning and mine research studies; underground miner at East Mine.
1972-1973	Junior Engineer, Iron Ore Co. of Canada Ltd., Schefferville, Quebec. Pit Engineer and Geologist at Redmond Mine.
Summer 1971	Junior Engineer – Mines, International Nickel Co. of Canada, Ltd., Copper Cliff, Ontario. Performed surveying at Crean Hill Mine and Ellen Pit.
Summer 1970	Underground Miner, Falconbridge Nickel Mines, Ltd., Falconbridge, Ontario.
Summer 1969	Underground Miner, Kam-Kotia Mines Ltd., Timmins, Ontario.

<u>Selected Publications</u>

Author of over 35 publications on mine opening and pillar design, mine ventilation and cooling, shaft design, hazardous waste site remediation, and nuclear waste disposal including:

Kendorski, F. S., and D. F. Hambley, 1992. "Other Applications of Geomechanics," Chapter 10.7 in *SME Mining Engineering Handbook*, Second Edition, SME, Littleton, CO, 975-991.

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ATTACHMENT B

Contentions Adopted By **Doug F. Hambley** In Accordance With Affidavit
NEV-SAFETY-61
NEV-SAFETY-62
NEV-SAFETY-63
NEV-SAFETY-64
NEV-SAFETY-77
NEV-SAFETY-90
NEV-SAFETY-121
NEV-SAFETY-122
NEV-SAFETY-123
NEV-SAFETY-128
NEV-SAFETY-131
NEV-SAFETY-132
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NEV-SAFETY-143
NEV-SAFETY-144
NEV-SAFETY-145
NEV-SAFETY-147
NEV-SAFETY-148
NEV-SAFETY-168
NEV-SAFETY-173
NEV-SAFETY-199

Attachment 10

Affidavit of Don L. Shettel, Jr.

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF DON L. SHETTEL, JR.

I, Don L. Shettel, Jr., the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Don L. Shettel, Jr., and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Don L. Shettel, Jr.

Don L. Shettel, Jr.

The above-named affiant personally appeared before me this 11th day of December, 2008, and executed this affidavit.

Rebecca A. Hartig

Notary Public

My Commission expires: 9-1-2012

REBECCA A. HARTIG
Notary Public, State of Nevada
Appointment No. 00-64882-1
My Appt. Expires Sep 1, 2012

ATTACHMENT A

CURRICULUM VITAE

DON L. SHETTEL

Don L. Shettel

Employment History and Professional Experience

Fall 2008	Adjunct Professor of Geology: College of Southern Nevada, Las Vegas, NV.
7/91-	Consulting Geochemist: GeoData Systems, Boulder City, NV. Experience: Technical expert for Egan, Fitzpatrick, and Malsch, PLLC, regarding the proposed high-level nuclear waste repository at Yucca Mountain, NV, for the State of Nevada. Evaluated groundwater and sediment geochemical data from east-central Minnesota for potential mineral exploration targets. Computer consultant.
6/91-12/07	Senior Geochemist, Project Manager, Chairman, and Vice President: Geosciences Management Institute, Inc., Boulder City, NV. Experience: Review technical documents of U.S. Dept. of Energy and their subcontractors related to the proposed high-level nuclear waste repository at Yucca Mountain, NV. Planned, designed, and helped install lysimeters in two shallow holes in Area 25 for sampling soil waters above the repository footprint of Yucca Mountain. Set up field procedures for sampling groundwater and sampled Early Warning Drilling Program wells for Nye Co. Nuclear Waste Repository Project Office. Reviewed technical documents concerning geochemistry, hydrogeology, and geostatistics, and performed geochemical modeling and geostatistical calculations for a low-level radioactive waste disposal facility in Wake/Chatham Counties, North Carolina. Made presentations at technical meetings and at high-level governmental agencies. Evaluated pit water geochemistry of a gold mine in southern California for environmental problems. Monitor and evaluate federal environmental assessment and site characterization efforts at the Yucca Mountain proposed nuclear waste repository. Principal investigator/manager of three contracts with Nye County (NV) Nuclear Waste Repository Project Office. Appeared as expert witness before the Shorelines Advisory Board, State of Washington.
8/92-10/93	Geochemist (part-time): Energy & Environmental Services Corp., Columbus, OH. Experience: Performed geochemical modeling (utilizing EQ3/6) to determine source terms for transport modeling and risk assessment of the Fernald Environmental Remediation Site, OH.
9/86-6/91	Senior Geochemist, Associate, and Treasurer: Mifflin & Associates, Inc., Las Vegas, NV. Experience: Co-manager of geochemical research on the suitability of Yucca Mountain as the nation's first high-level nuclear waste repository. Perform hydrogeochemical modeling (on both mainframe and personal computers) of the vadose zone to help assess the extent of “disturbed zone” for the high-level nuclear waste repository. Oversaw development of a quality assurance and quality control program for a vadose zone drilling and sampling project in the vicinity of Yucca

Mountain. Prepare or assist in the preparation of research proposals and budgets for submission to state or federal governmental agencies for funding. Managed subcontracts to research scientists at major universities: Virginia Polytechnic Institute and State University, University of Toronto, and University of Oregon. Principal Investigator on U.S.D.A. Forest Service project for archaeological damage assessment of the *Exxon Valdez* oil spill in Alaska. Supervised drilling crew on water supply project.

1/82-
7/86

Senior Research Geochemist: Reservoir Diagenesis Section, Exxon Production Research Company, Houston, TX.
Experience: Investigated sandstone diagenesis by geochemical modeling, isotopic methods, mass balance calculations, and microscopy. Established a stable isotope laboratory for carbon and oxygen isotopic measurements on carbonates in rocks and calcareous microfossils that resulted in improved turnaround time and quality control of isotopic analyses. Developed model for carbonate cementation in sandstones based in part on stable isotope geochemistry and microscopy of sandstones from around the world. Made quarterly presentations to management. Taught portions of short courses. Supervised and trained a technician to operate a stable isotope laboratory.

6/78-
1/82

Staff Geoscientist: Data Integration Group, Geology Division, Bendix Field Engineering Corporation, Grand Junction, CO.
Experience: Interpreted over 250,000 hydrogeochemical and stream-sediment samples consisting of over 5 million analyses and reported results. Assisted in the development of mainframe computer software and standardization of statistical analysis procedures for the interpretation and display (including mapping) of geochemical exploration data to aid uranium resource assessment. Combined water-rock interaction computer models on a mainframe computer with standard interpretation techniques of geochemical data to assist uranium resource assessment. Directed three professionals and one technician in the development and use of software for interpretation of geochemical exploration data.

7/77-
5/78

Faculty Research Associate: Arizona State University, Department of Chemistry (Geochemistry Section), Tempe, AZ.
Experience: Designed and tested a mixing cell for performing calorimetry on geothermal brines.

9/71-
6/77

Graduate Research Assistant: Department of Geosciences, Pennsylvania State University, University Park, PA.
Experience: Participated in data collection of PVT properties of water at high temperatures and pressures. Conducted hydrothermal experiments and stable isotope mass spectrometry of H_2O-saturated magmas. Built fluorination line for oxygen isotopic analyses of silicates. Trained other research assistants in use of fluorination line for extraction of oxygen isotopes.

5/71- 8/71	Assistant Field Geologist: Mineral Exploration Division, Humble Oil & Refining Company, Bangor, ME. Experience: Conducted reconnaissance geologic mapping and geochemical and geophysical surveys that resulted in base metal prospects for drilling.

Education

1978	Ph.D. in Geochemistry and Mineralogy, The Pennsylvania State University, University Park, PA Dissertation: *Experimental determination of oxygen isotopic fractionation between H_2O and hydrous silicate melts*: 115 p. Thesis advisers: Drs. H. Ohmoto and C. Wayne Burnham.
1974	Masters of Science in Geochemistry, The Pennsylvania State University, University Park, PA Dissertation: *The solubility of quartz in supercritical H_2O-CO_2 fluids*: 52 p. Thesis Adviser: Dr. C. Wayne Burnham.
1971	Bachelors of Science in Geology (with honors), University of Michigan, Ann Arbor, MI Honors Adviser: Dr. William C. Kelly.

Professional Affiliations
American Association for the Advancement of Science
American Geophysical Union
Association of Engineering Geologist
Association of Exploration Geochemists
Geochemical Society
International Association of Geochemistry and Cosmochemistry
International Association of Mathematical Geologists

License
Registered Geologist, State of Washington, #1466

Recent Short Courses
Groundwater Hydrology and Pollution: by Princeton Groundwater, Inc., San Francisco, CA, Summer 2007.
Groundwater Remediation: by Princeton Groundwater, Inc., Las Vegas, NV, Summer 2008.

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Publications:

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Morgenstein, M. E. and Shettel, D. L., Jr., 1989. Review of: Licensing Support System Prototype Thesaurus by Science Applications International Corporation, 25 January 1989, 51p.

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Mifflin & Associates, Inc., 1988. Review of: Consultation Draft of the Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada (DOE/RW-0160, Jan. 1988), 247p.

Mifflin & Associates, Inc., 1987. Technical Review Comments on the Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada (May 1986, Vols. I, II, III [DOE/RW-0073]), 187p., for Nevada NWPO

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Langfeldt, S.L, Youngquist, C.A., Shettel, D.L., Jr., Zinkl, R.J., D'Andrea, R.F., et al., 1981, Uranium hydrogeochemical and stream sediment reconnaissance of the Solomon N.T.M.S. Quadrangle, Alaska: U. S. Dept. of Energy, Grand Junction, CO., GJBX-188(81), 50 p., 7 pl.

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D'Andrea, R.F., Youngquist, C.A., Langfeldt, S.L, Shettel, D.L., Jr., Zinkl, R.J., et al., 1981, Uranium hydrogeochemical and stream sediment reconnaissance of the Cordova N.T.M.S. Quadrangle, Alaska: U. S. Dept. of Energy, Grand Junction, CO., GJBX-185(81), 67 p., 7 pl.

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ATTACHMENT B

Contentions Adopted By **Don L. Shettel** In Accordance With Affidavit
NEV-SAFETY-42
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NEV-SAFETY-141

Attachment 11

Affidavit of Eugene I. Smith

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF EUGENE I. SMITH

I, Eugene I. Smith, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Eugene I. Smith, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

E. I. Smith

Eugene I. Smith

The above-named affiant personally appeared before me this 11TH day of December, 2008, and executed this affidavit.

MARILYN M. MARTYN
Notary Public State of Nevada
No. 05-94356-1
My appt. exp. Feb. 15, 2009

Marilyn M. Martyn

Notary Public

My Commission expires: 2/15/09

ATTACHMENT A

CURRICULUM VITAE

EUGENE I. SMITH

CURRICULUM VITAE
EUGENE I. SMITH

Mailing Address:	Department of Geoscience University of Nevada (UNLV) Las Vegas, Nevada 89154-4010 gene.smith@unlv.edu
Telephone:	office: (702) 895-3971 FAX: (702)) 895-4064

Educational Background:

University	Degree	Year
University of New Mexico	Ph.D.	1970
University of New Mexico	M.S.	1968
Wayne State University	B.S.	1965

Specialties:, Volcanology, Igneous Petrology, Geochemistry, Tectonics, Planetary Geology

Professional Experience:

8/88 to present:	Professor of Geology, UNLV
7/83-7/86:	Chair, Department of Geoscience, UNLV
9/80 to 8/88:	Associate Professor of Geology, UNLV
9/76-8/80:	Associate Professor of Earth Science, University of Wisconsin-Parkside
9/72-9/76:	Assistant Professor of Earth Science, University of Wisconsin-Parkside
9/70-6/72:	Post-doctoral Research Associate to Professor W.E. Elston, Department of Geology, University of New Mexico
9/68-8/70:	Graduate Research Assistant to Professor W.E. Elston, Department of Geology, University of New Mexico
8/68-8/80:	Geologist WAE, U.S. Geological Survey, Branch of Astrogeology, Flagstaff, AZ

6/66-7/68:	Geological Field Assistant WAE, U.S. Geological Survey, Branch of Astrogeology, Flagstaff, AZ
6/64-9/64:	Undergraduate Research Assistant to Professor A.J. Mozola, Department of Geology, Wayne State University, Detroit, MI

Professional Society Memberships:

American Association for the Advancement of Science
American Geophysical Union
Geological Society of America (Fellow)
Geological Society of Nevada
IAVCEI-International Association of Volcanology and Chemistry of the Earth's Interior
Mineralogical Society of America
Phi Kappa Phi
Sigma Gamma Epsilon
Sigma Xi

Grants:

- Bureau of Land Management contract to study the geology of the Sloan Canyon NCA (2006-2008).
- Bureau of Land Management contract to study the geology of the Sloan Canyon NCA (2005)
- Nevada Agency for Nuclear Projects grant to study basaltic volcanism in the Great Basin (2000-2001).
- U.S. Navy Geothermal Office Grant to study volcanic rocks in the Lava Mountains, (1998-1999.
- U.S. Navy Geothermal Office Grant *with Rodney Metcalf* to study volcanic rocks in the Lava Mountains, California and the Mt. Perkins Pluton, Arizona (1996-1998).
- Grants from Nevada Nuclear Waste Project Office (NWPO) to study late- Miocene and younger volcanic activity in southern Nevada (ten years of funding) (1985-1996).
- NSF Grant with J. Faulds and P. Gans to study the structural and geochemical development of the northern Colorado River extensional corridor (1991-1993).
- UNLV Research Council grant to support the study of Tertiary volcanic rocks in Clark County, Nevada (1983).
- NASA Grant NGR 50-009-001 for the study of volcanic fields in California, New Mexico and Wisconsin. The grant also funded the study of volcanic domes and craters on Mars, Mercury, Moon and Earth (6 years of funding)(1973-1979).
- Four University of Wisconsin research grants to support the study of Precambrian igneous rocks of south-central Wisconsin (1973-1977).

Awards:

- Recipient of the Harry Reid Nevada Star Award for Research (2006).
- Recipient of UNLV College of Sciences Distinguished Researcher Award, 1999.
- National Defense Education Act (NDEA) Title IV Fellowship, 9/65-6/68

Current Research:

1. Geology of Quaternary-Pliocene basalts in the southern and central Great Basin and Colorado Plateau.
2. Volcanic hazard studies related to placing a nuclear waste repository at Yucca Mountain, Nevada.
3. Geology of basalts in the Yellowstone Plateau volcanic field, implications for the future development of the Yellowstone volcanic system.
4. Geochemical, structural and field study of the volcanic and plutonic rocks of the Lake Mead Volcanic Field.
5. The formation of intermediate composition igneous rocks in an extensional environment.

Editorial Responsibilities

- Associate editor of the Geological Society of America Bulletin 1999-2008
- Associate editor of the Journal of Geophysical Research (Geochemistry and Volcanology)- 1996-1999

Research Advisor for the following students:

University of New Mexico:
- Anthony Sanchez

University of Wisconsin-Parkside:
- James Grimes
- Bill Stupak
- Jill Hartnell
- Ray Spangers
- Cliff Brandon

UNLV:
- **Crow, H. Clay, III**, 1984, *Geochemistry of shonkinites, syenites, and granites associated with the Sulfide Queen carbonatite body, Mountain Pass, California [MS thesis]*: Las Vegas, University of Nevada, 56 p.
- **Myers, Ingrid A.**, 1984, *Geology and mineralization at the Cyclopic mine, Mohave County, Arizona [MS thesis]*: Las Vegas, University of Nevada, 64 p.
- **Mills, James G., Jr.**, 1985, *The geology and geochemistry of volcanic and plutonic rocks in the Hoover Dam 7 1/2 minute quadrangle, Clark County, Nevada and Mohave County, Arizona [MS thesis]*: Las Vegas, University of Nevada, 119 p.

- **Timm, John J.**, 1985, *Age and significance of paleozoic sedimentary rocks in the southern River Mountains, Clark County, Nevada [MS thesis]*: Las Vegas, University of Nevada, 62 p.
- **Feuerbach, Daniel L.**, 1986, *Geology of the Wilson Ridge pluton : a mid-Miocene quartz monzonite intrusion in the northern Black Mountains, Mohave County, Arizona and Clark County, Nevada [MS thesis]*: Las Vegas, University of Nevada, 79 p.
- **Naumann, Terry R.**, 1987, *Geology of the central Boulder Canyon quadrangle, Clark County, Nevada [MS thesis]*: Las Vegas, University of Nevada, 68 p.
- **Schmidt, Casey S.**, 1987, *A mid-Miocene caldera in the central McCullough Mountains, Clark County, Nevada [MS thesis]*: Las Vegas, University of Nevada, 78 p.
- **Sewall, Angela J.**, 1988, *Structure and geochemistry of the upper plate of the Saddle Island detachment, Lake Mead, Nevada [MS thesis]*: Las Vegas, University of Nevada, 84 p.
- **Cole, Erin D.**, 1989, *Petrogenesis of late Cenozoic alkalic basalt near the eastern boundary of the Basin-And-Range: Upper Grand Wash trough, Arizona and Gold Butte, Nevada [MS thesis]*: Las Vegas, University of Nevada, 68 p.
- **Larsen, Lance L.**, 1989, *The origin of the Wilson Ridge pluton and its enclaves, northwestern Arizona: Implications for the generation of a calc-alkaline intermediate pluton in an extensional environment [MS thesis]*: Las Vegas, University of Nevada, 81 p.
- **Bridwell, Hayden L.**, 1991, *The Sloan Sag: A mid-Miocene volcanotectonic depression, north-central McCullough Mountains, southern Nevada [MS thesis]*: Las Vegas, University Of Nevada, 147 p.
- **Cascadden, Tracy E.**, 1991, *Style of volcanism and extensional tectonics in the eastern Basin and Range Province: northern Mojave Co., Arizona [MS thesis]*: Las Vegas, University Of Nevada, 156 p.
- **Morikawa, Shirley A.**, 1993, *The Geology of the Tuff of Bridge Spring: southern Nevada and northwestern Arizona [MS thesis]*: Las Vegas, University of Nevada, 165 pp.
- **Rash, Kelly B.**, 1995, *Geology and geochemistry of Tertiary volcanic rocks in the northern Reveille and southern Pancake Ranges, Nye County, Nevada [MS thesis]*: Las Vegas, University of Nevada, 171 p.
- **Sánchez, Alexander**, 1995, *Mafic volcanism in the Colorado Plateau / Basin-and-Range transition zone, Hurricane, Utah [MS thesis]*: Las Vegas, University of Nevada, 92 p.
- **Boland, Kelly A.**, 1996, *The petrogenesis of andsites produced during regional extension: Examples from the northern McCullough Range, Nevada and Xitle volcano, Mexico [MS thesis]*: Las Vegas, University of Nevada, 127 p.
- **Dickson, Loretta D.**, 1997, *Volcanology and geochemistry of Pliocene and Quaternary basalts on Citadel Mountain, Lunar Crater volcanic field, Pancake Range, Nevada [MS thesis]*: Las Vegas, University of Nevada, 146 p. (Received the UNLV Alumni Association award for the most outstanding thesis for the academic year 1997-98)
- **Downing Reina**, 2000, *Imaging the Mantle in Southwestern, Utah Using Geochemistry, and Geographic Information Systems* [MS thesis]: Las Vegas, University of Nevada, 129 p.
- **Keenan, Deborah L.**, 2000, *A study of the Lava Mountians, San Bernadino County, California* [MS thesis]: Las Vegas, University of Nevada, 81p.
- **Herrington, Juliana**, 2000, *Significance of the prevolcanic conglomerate of the Colorado River extensional corridor, Nevada and Arizona* [MS thesis]: Las Vegas, University of Nevada, 83p.

- **Sanford, Aaron L.**, 2000, *Geologic history of the McCullough Pass caldera* [MS thesis]: Las Vegas, University of Nevada, 111p.
- **Elizabeth Stickney**, 2004, *Quaternary basaltic volcanism in the northern part of the Lunar Crater volcanic field, Nevada*:, 103 p.
- **Matt Faust,** 2005, *Petrogenesis and geochemistry of Pleistocene and Pliocene basalt flows of the Pine Valley Volcanic Field, Utah and their relationship to the tectonics of the Utah Transition Zone* [MS thesis]: University of Nevada), 116 p.
- **Denise Honn,** 2005, *Nested Calderas of the northern Kawich Range, central Nevada* [MS thesis]: Lasa Vegas, University of Nevada, 92 p.
- **Denise Honn Ph.D**. *Linking a volcanic-plutonic system in the River Mountains and Wilson Ridge Pluton*. (work in progress).
- **Shara Leavitt**, 2006, *Volcanology and Petrogenesis of the Navajo Lake Volcanic Field, Utah* : [MS thesis]: Las Vegas, University of Nevada, 94 p.
- **Kristeen Bennett**, 2006, *Petrogenesis of Pleistocene basalts in the Norris-Mammoth Corridor, Yellowstone National Park* : [MS thesis]: Las Vegas, University of Nevada, 120 p.
- **Matt McKelvey,** *Geology of the southern Reveille Range, Nevada:* [MS thesis]: Las Vegas, University of Nevada, 103 p..
- **Audrey Rager (Ph.D.),** *Basalts, tectonics and Corona on Venus, How is important is plate tectonics* (work in progress).
- **Ashley Tibbetts (Ph.D.),** *Geology of the Death Valley volcanic field (work in progress).*
- **Christi Emery,** *Volcanology of the southern Quinn Canyon Range, central Nevada (work in progress).*
- **Racheal Johnsen,** *Volcanology of two volcanic fields in SW Utah, implications for tectonics and mantle source (work in progress).*

Students who left UNLV before completing their degrees

- Jeff Nejedly
- Robert Yasek
- Tom Wickham
- Joe Blaylock
- Heather Putnam

Post-Doctoral Research Associates

- Jim Faulds (now an research scientist with the Nevada Bureau of Mines and Geology)
- Mark Martin (now a research fellow at MIT)
- Jim Mills (now an associate professor at DePauw University, Indiana)
- Tim Bradshaw (now a science advisor to the House of Lords, London)
- Gene Yogodzinski (now an assistant professor at the University of South Carolina)

Research Associates *(Professional Staff with M.S. degrees)*

- Dan Feuerbach
- Terry Naumann
- Alex Sánchez

- Shirley Morikowa
- Deb Keenan
- Denise Honn

PUBLICATIONS:

A. Journal Articles in refereed journals, symposium volumes and maps:

1. Elston, W.E., Lambert, P.W. and Smith, E.I., 1968, Striated cones: wind abrasion features, not shatter cones: in Short, N.M., and French, B.M., eds., Shock Metamorphism of Natural Materials, Mono Book Corporation, Baltimore, p. 287- 290.

2. Mozola, A.J. and Smith, E.I., 1969, Glacial drift thickness map of Wayne County, Michigan: in Mozola, A.J., Geology for land and ground-water development in Wayne County, Michigan: Geological Survey of Michigan, Report of Investigation 3, 25 pp.

3. Elston, W.E., and Smith, E.I., 1970, Determination of flow direction of rhyolite ash-flow tuffs from fluidal textures: Geological Society of America Bulletin, v. 81, p. 3393- 3406.

4. Elston, W.E., Aldrich, M.J., Smith, E.I. and Rhodes, R.C., 1971, Non-random distribution of lunar craters: Journal of Geophysical Research, v. 76, no. 23, p. 5675-5682.

5. Smith, E.I., 1971, Determination of the origin of small lunar and terrestrial craters by depth-diameter ratio: Journal of Geophysical Research, v. 76, no. 23, p. 5683- 5689.

6. Rhodes, R.C., and Smith, E.I., 1972, Directional fabric of ash-flow sheets in the northwest part of the Mogollon Plateau, New Mexico: Geological Society of America Bulletin, v. 83, p. 1863-1868.

7. Smith, E.I., and Rhodes, R.C., 1972, Flow direction of lava flows: Geological Society of America Bulletin, v. 83, p. 1869-1874.

8. Rhodes, R.C., and Smith, E.I., 1973, Geology and tectonic setting of the Mule Creek Caldera, New Mexico, USA: Bulletin Volcanologique, v. 36, no. 3, p. 401-411.

9. Smith, E.I., 1973, Mono Craters, California: A new interpretation of the eruptive sequence: Geological Society of America Bulletin, v. 84, p. 2685-2690.

10. Smith, E.I., 1973, Identification, distribution and significance of lunar volcanic domes: The Moon, v. 6, nos. 1/2, p. 3-31.

11. Smith, E.I., and Sanchez, A.G., 1973, Fresh lunar craters: morphology as a function of diameter, a possible criterion for crater origin: Modern Geology, v. 4, p. 51-59.

12. Elston, W.E., Damon, P.E., Coney, P.J., Rhodes, R.C., Smith, E.I., and Bickerman, M., 1973, Tertiary volcanic rocks, Mogollon Plateau, New Mexico and surrounding regions: K-Ar dates and patterns of eruption: Geological Society of America Bulletin, v. 84, p. 2259-2274.

13. Elston, W.E., and Smith, E.I., 1973, Mars, evidence for dynamic processes from Mariners 6 and 7: Icarus, v. 19, p. 180-194.

14. Smith, E.I., and Rhodes, R.C., 1974, The Squirrel Springs volcanotectonic depression, a buried cauldron in southwestern New Mexico: Geological Society of America Bulletin, v. 85, p. 1865-1868.

15. Smith, E.I., 1974, Rumker Hills, a lunar volcanic dome complex: The Moon, v. 10, no. 2, p. 175-182.

16. Smith, E.I., and Sanchez, A.G., 1975, Fresh lunar craters: morphology as a function of diameter, a possible criterion for crater origin, Reply: Modern Geology, v. 5, p. 175-176.

17. Smith, E.I., 1976, Comparison of the crater morphology-size relationship for Mars, Moon and Mercury: Icarus, v. 28, p. 543-550.

18. Rhodes, R.C., and Smith, E.I., 1976, Stratigraphy and structure of the northwestern rim of the Mogollon Plateau volcanic province, Catron County, New Mexico: New Mexico Geological Society Special Publication No. 5, p. 57-62.

19. Smith, E.I., 1976, Structure and morphology of the John Kerr Peak dome complex, southwestern New Mexico: New Mexico Geological Society Special Publication No. 5, p. 71-78.

20. Smith, E.I., Aldrich, M.J., Deal, E.G., and Rhodes, R.C., 1976, Fission track ages of Tertiary volcanic rocks, Mogollon Plateau, southwestern New Mexico: New Mexico Geological Society Special Publication No. 5, p. 117-118.

21. Smith, E.I., 1978, Introduction to the Precambrian rocks of south-central Wisconsin: Geoscience Wisconsin, v. 2, p. 1-17.

22. Smith, E.I., Paull, R.A., and Mudrey, M.G., 1978, Precambrian inliers in south-central Wisconsin: Wisconsin Natural History and Geological Survey Field Trip Guide Book No. 2, 89 pp.

23. Smith, E.I., 1978, Precambrian rhyolites and granites in south-central Wisconsin: field relations and geochemistry: Geological Society of America Bulletin, v. 89, p. 975- 980.

24. Smith, E.I., and Stupak, W.A., 1978, A Fortran IV program for the classification of volcanic rocks using the Irvine and Baragar classification: Computers and Geoscience, v. 4, p. 89-99.

25. Smith, E.I., and Hartnell, J.A., 1978, Crater size-shape profiles for the Moon and Mercury: The Moon and Planets, v. 19, p. 479-511.

26. Smith, E.I., Slagle, M.J., and Luzader, S., 1980, Impact cratering experiment for a course in lunar and planetary geology: Journal of Geological Education, v. 28, p. 204-209.

27. Bell, J., and Smith, E.I., 1980, Geological map of the Henderson quadrangle, Clark County, Nevada: Nevada Bureau of Mines and Geology, Map 67.

28. Parolini, J.R., Smith, E.I., and Wilbanks, J.R., 1981, Fission track dating of gravity slide blocks in the Rainbow Gardens, Clark County, Nevada: Isochron/West, no. 30, p. 9-10.

29. Smith, E.I., 1982, Geology and geochemistry of the volcanic rocks in the River Mountains, Clark County, Nevada and comparisons with volcanic rocks in nearby areas: in Frost, E.G., and Martin, D.L. eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River Region, California, Arizona and Nevada: San Diego, California, Cordilleran Publishers, p. 41-54.

30. Smith, E.I., 1984, Geochemistry and evolution of the early Proterozoic Post-Penokean rhyolites and granites, and related rocks of south-central Wisconsin: Geological Society of America Memoir 160, p. 113-128.

31. Smith, E.I., 1984, Geologic map of the Boulder City quadrangle, Nevada: Nevada Bureau of Mines and Geology, Map 81.

32. Choukroune, Pierre, and Smith, E.I., 1985, Detachment faulting and its relationship to older structural events on Saddle Island, River Mountains, Clark County, Nevada: Geology, v. 13, p. 421-424.

33. Myers, I.A., Smith, E.I., and Wyman, R.V., 1986, Control of gold mineralization at the Cyclopic Mine, Gold Basin District, Mohave County, Arizona: Economic Geology, v. 81, no. 6, p. 1553-1557.

34. Smith, E.I., 1986, Field Guide to the Geology of the eastern River Mountains and the Hoover Dam area, Clark County, Nevada: in Rowland, S.R., Field Guide to the Geology of Southern Nevada, prepared for the NAGT-FWS Meeting, Las Vegas, Oct. 3-5, 1986, p. 22-64.

35. Smith, E.I., Anderson, R.E., Bohannon, R.J. and Axen, Gary, 1987, Structure, volcanology, and sedimentology of mid-Tertiary rocks in the eastern Basin-and- Range Province, Southern Nevada: in Davis, G.H. and VandenDolder, Geologic Diversity of

Arizona and its Margins: Excursions to Choice Areas: Arizona Bureau of Geology and Mineral Technology, Geological Survey Branch Special Paper 5, p. 383-397.

36. Weber, M.E., and Smith, E.I. 1987, Structural and geochemical constraints on the reassembly mid-Tertiary volcanoes in the Lake Mead area of southern Nevada: Geology, v. 15, p. 553-556.

37. Guth, Peter and Smith, E.I., 1987, Discussion of the paper by Ron and others, "Strike-slip faulting and block rotation in the Lake Mead Fault System", Geology, v. 15, p. 579-580.

38. Smith, E.I., Schmidt, C.S., and Mills, J.G., 1988, Mid-Tertiary volcanoes of the Lake Mead area of southern Nevada and Northwestern Arizona: in Weide, D.L., and Faber, M.L., This Extended Land, Geological Journeys in the southern Basin and Range, Geological Society of America, Cordilleran Section Field Trip Guidebook; UNLV Department of Geoscience, Special Publication No. 2, p. 107-122.

39. Faulds, J.E., Hillemeyer, F.L., and Smith, E.I., 1988, Geometry and kinematics of a Miocene "Accommodation Zone" in the central Black and southern Eldorado Mountains, Arizona and Nevada: in Weide, D.L., and Faber, M.L., This Extended Land, Geological Journeys in the southern Basin and Range, Geological Society of America, Cordilleran Section Field Trip Guidebook; UNLV Department of Geoscience, Special Publication No. 2, p. 293-310.

40. Smith, E.I., Feuerbach, D.L., Naumann, T.R. and Faulds, J.E., 1990, The area of most recent volcanism about Yucca Mountain, Nevada: Implications for volcanic risk assessment: in Proceedings of the International Nuclear Waste Symposium, v. 1, American Nuclear Society and American Society of Civil Engineers, p. 90-97.

41. Smith, E.I., Feuerbach, D.L, Naumann, T.R. and Mills, J.E., 1990, Geochemistry and evolution of mid-Tertiary igneous rocks in the Lake Mead area of Nevada and Arizona: in Anderson, J.L., Cordilleran Magmatism: Geological Society of America Memoir 176, p. 169-194.

42. Larsen, L.L. and Smith, E.I., 1990, Mafic enclaves in the Wilson Ridge Pluton, northwestern Arizona: Implications for the generation of a calc-alkaline intermediate pluton in an extensional environment: Journal of Geophysical Research, v. 95, p. 17693-17716.

43. Duebendorfer, E.M., Sewall, A.J., and Smith, E.I., 1991, The Saddle Island Detachment fault, an evolving shear zone in the Lake Mead area of southern Nevada: in Wernicke, B., Mid-Tertiary extension at the latitude of Las Vegas: Geological Society of America Memoir 176, p. 77-97.

44. Duebendorfer, E.M. and Smith, E.I., 1991, Tertiary structure, magmatism and sedimentation in the Lake Mead region, southern Nevada, in Seedorf, E., ed., Tertiary

geology and volcanic-hosted gold deposits of the southern Great Basin: Geological Society of Nevada Special Publication 13, p. 66-95.

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C. Open File and Technical Reports

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2. Eggleton, R.E., and Smith, E.I., 1967, Geologic map of the Rumker Quadrangle of the Moon: U.S. Geological Survey Open File Report.

Plus over 300 reports to the Nevada Nuclear Project Office, U.S. Navy's Geothermal Project Office and the Bureau of Land Management.

ATTACHMENT B

Contentions Adopted By **Eugene I. Smith** In Accordance With Affidavit
NEV-SAFETY-150
NEV-SAFETY-151
NEV-SAFETY-152
NEV-SAFETY-153
NEV-SAFETY-154
NEV-SAFETY-155
NEV-SAFETY-156
NEV-SAFETY-157
NEV-SAFETY-158

Attachment 12

Affidavit of Hugh Horstman

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of U.S. DEPARTMENT OF ENERGY License Application to Construct a Geologic Repository at Yucca Mountain	))))))))	Docket No. 63-001

AFFIDAVIT OF HUGH HORSTMAN

I, Hugh Horstman, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Hugh Horstman, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Hugh Horstman

The above-named affiant personally appeared before me this 11 day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: July 2, 2011

BENJAMIN A GOCHBERG
Notary Public
State of Utah
My Commission Expires July 02, 2011
1500 N Hillfield Rd, Layton, UT 84041

ATTACHMENT A

CURRICULUM VITAE

HUGH HORSTMAN

Hugh Horstman
3538 Copper Mountain Circle
Mt Green, Utah 84050
801 309 3934

2006 – Present
Aviation Safety Consultant, State of Nevada
Expert Witness for Aviation Crash Hazards

1999 – Present
Captain, Southwest Airlines
Boeing 737 pilot

2003 – 2006
Secretary/Treasurer, Southwest Airlines Pilots Association
Executive officer for 6,000 pilots association with $10M annual budget

1999 – 2005
Aviation Safety Consultant, State of Utah
Expert Witness for Aviation Crash Hazards

1999 – 2003
Commissioner, Layton Planning Commission, Layton, Utah
Property and land use commissioner

1978 – 1999 United States Air Force
Lieutenant Colonel (Retired)
Instructor Pilot: F-111 and F-16 Aircraft
Deputy Commander, F-16 Fighter Operations Group, Hill AFB, Utah
Deputy Commander, Support Group, Spangdahlem Air Base Germany

Flight Experience
Over 10,000 flight hours: B-52, F-111, F-16, Mig 29, T-37, T-38, Boeing 737

Education
1978 Bachelor of Science, Business Administration, University of Southern California
1982 Master of Arts Business Administration, Central Michigan University
1992 Air Command and Staff College, Maxwell AFB Alabama
1993 – 1997 Adjunct Professor, Embry Riddle Aeronautical University

ATTACHMENT B

Contentions Adopted By **Hugh Horstman** In Accordance With Affidavit
NEV-SAFETY-174
NEV-SAFETY-175
NEV-SAFETY-176
NEV-SAFETY-177
NEV-SAFETY-178
NEV-SAFETY-179
NEV-SAFETY-180
NEV-SAFETY-181
NEV-SAFETY-182
NEV-SAFETY-183
NEV-NEPA-23

Attachment 13

Affidavit of Howard S. Wheater

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF HOWARD S. WHEATER

I, Howard S. Wheater, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Howard S. Wheater, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Howard S. Wheater

The above-named affiant personally appeared before me this 26th day of November, 2008, and executed this affidavit.

Notary Public

My Commission expires: with life.

PAWEL K. SALINGER
NOTARY PUBLIC

PAWEL K. SALINGER
NOTARY PUBLIC
15 KENSINGTON HIGH STREET
LONDON W8 5NP
ENGLAND

ATTACHMENT A

CURRICULUM VITAE

HOWARD S. WHEATER

Curriculum Vitae

PROFESSOR H.S. WHEATER

Name:	Howard Simon Wheater
Date of Birth:	24.6.49
Nationality:	British
Present Appointment:	Professor of Hydrology, Department of Civil & Environmental Engineering, Imperial College, University of London Head, Environmental and Water Resource Engineering Section, Department of Civil & Environmental Engineering, Imperial College Chairman, Centre for Environmental Control and Waste Management, Imperial College Director, MSc in Hydrology for Environmental Management, Imperial College

Degrees:

B.A.	(1st Class Honours) Engineering Science University of Cambridge	1971
M.A.	University of Cambridge	1974
Ph.D.	University of Bristol	1977

Awards:

Rolls-Royce Industrial Scholarship	1968
Entrance Exhibition, Queens' College, Cambridge	1968
Senior Scholarship, Queens' College, Cambridge	1971
Institution of Civil Engineers Overseas Premium	1984
British Hydrological Society President's Prize	1996
Institution of Civil Engineers Baker Medal	2004
Prince Sultan bin Abdulaziz International Water Prize	2006

Membership of Professional Bodies and Learned Societies:

Fellow, Royal Academy of Engineering (FREng)	2003
Life Member, International Water Academy (Oslo)	1999
Fellow, Institution of Civil Engineers (C.Eng, FICE) (Member 1978)	1999
Member, British Hydrological Society	1983
Fellow, Royal Meteorological Society	1985
Member, American Geophysical Union	1983

Appointments:

1978-	**Imperial College of Science, Technology & Medicine**
1993-	Professor of Hydrology
1990-1993	Reader in Engineering Hydrology, Department of Civil Engineering
1987-1990	Senior Lecturer in Engineering Hydrology, Department of Civil Engineering
1978-1987	Lecturer in Engineering Hydrology, Department of Civil Engineering
1972-1978	**University of Bristol, Department of Civil Engineering**
1976-1978	Research Associate Integration of tidal power within the UK electricity generating network (SERC).
1975-1976	Research Assistant Regional analysis of rainfall-runoff relations. Effects of urbanization on flood runoff (Water Research Centre).
1972-1975	Research Assistant Research into catchment hydrology, physical simulation of hydrological processes, rainfall-runoff simulation techniques for flood management.
1968-1972	**Rolls-Royce Ltd (Aero Engine Division).** Engineering apprenticeship Fluid Mechanics research.
July 1978 to date	Present Appointment

Teaching:

Lecturer to Engineering Hydrology MSc/DIC Course
Lecturer to Environmental Engineering MSc/DIC Course
Lecturer to Environmental Technology MSc/DIC Course
Lecturer to Environmental Diagnosis MSc/DIC Course
Lecturer to Civil Engineering and Civil and Environmental Engineering, MEng

Current Research Group:

11 research students.
4 research assistants.

Current/Recent Research Grants & Contracts:

Radionuclide transport in vegetated soils
UK Nirex/ANDRA 1988-2007, £3.5 million
National Infrastructure for Catchment Hydrology Experiments (NICHE)/Lowland Catchment Research (LOCAR)
Joint Infrastructure Fund 1999-2004, £2 million

Hydrogeochemical functioning of lowland permeable catchments: from process understanding to environmental management
NERC/Environment Agency 2002-2006, £500k
Generation of spatially-consistent rainfall data,
DEFRA 2003-2006, £680K
Spatial-temporal rainfall modelling with climate change scenarios
DEFRA 2003-2006, £154K
Co-PI, £6million EPSRC Flood Risk Management Research Consortium
Land use management research, EPSRC Flood Risk Management Research Consortium, 2004-2008, £720k
Modelling groundwater flood risk from extreme events
NERC FREE thematic programme, 2007-2010, approx £600k

Research training: Approx 42 Ph.D students, 100 MSc projects (past and present).

College Administration: Department of Civil & Environmental Engineering
Head, Environmental & Water Resource Engineering Section,
Member, Departmental Management Committee
Chairman, Departmental Examiners' Board
Chairman, Centre for Environmental Control and Waste Management
Director, Engineering Hydrology MSc/DIC Course (1984-date)
Previously Chair, Departmental Research Committee
Imperial College
Chair, Faculty Environment Forum
Member, College Climate Change Research Steering Group
Founder, College ENTRUST Panel
Member, various College research centres and initiatives

Learned Society Activities, UK and International Scientific Administration:
British Hydrological Society
President 1999-2001
Chairman, Southern Section, 1984-96
Chairman, Research Sub-Committee, 1994-1999
Chairman, Scientific Programme Committee, Intnl Conf on Hydrology in a Changing Environment, Exeter, 1998
Chairman, Itnl Conf on Hydrology, Science and practice for the 21st century, Imperial College London, 2004
Chartered Institute of Water and Environmental Management
Member, Water Resources Panel, 1999-2001
Institution of Civil Engineers
Member, Water Board, 1999-2001
Member, Reservoir Safety Advisory Panel, 2000 -
Natural Environment Research Council
Chairman, Land & Water Resources Review Panel, Centre for

Ecology and Hydrology,1996-2003
Member, CEH Programme Development Group, 2003-
Chairman, LOCAR Working Group, 1998-9 (initiated £10million national research programme)
Member, Freshwater Sciences Research Grants & Training Awards Committee, 1993-7
Member, HYREX Programme Committee, 1992-6
Member, Environmental Diagnostics Programme Committee, 1995-2000
Member, LOCAR Programme Committee, 1999-
Member, FREE Ad-hoc steering group, 2002-2004
Ministry of Agriculture, Fisheries and Food
Member, Flood Estimation Handbook Advisory Committee, 1994-1999

Environment Agency of England and Wales
Member, Flood Warning and Management
R&D Advisory Group, 1999-2001
Member, Scientific Advisory Panel, 2004-
Member, Nitrate Vulnerability Assessment Advisory Panel 2006

Department of Environment, Food and Rural Affairs/EA Broad Scale Modelling
Thematic Advisory Group 2000-2005
Chair, Criteria Review Panel (development of guidelines for exclusion criteria for the siting of a subsurface repository for high and intermediate level nuclear waste) 2007

UNESCO
Member, International Hydrological Programme Advisory Panel, 2002-
Chair, G-WADI Steering Committee, 2002-
Reviewer, Flemish Government Trust Fund
Member, UNESCO Mission to Sudan, 2007

Scientific Advisor to the Ministry of Foreign Affairs, Republic of Hungary with respect to the Gabcikovo-Nagymaros Barrage System (GNBS) case and Counsel and Advocate for Hungary, at the International Court of Justice, The Hague, 1993-97

Scientific Advisor to the Republic of Argentina with respect to environmental impacts of proposed industrial developments on R Uruguay water quality at the International Court of Justice, The Hague, 2006-

Consultant to the State of Nevada, USA concerning a proposed US Department of Environment licence application for a nuclear waste repository at Yucca Mountain, 2003-

Editorial Activities:

International Board of Advisers, ASCE Journal of Hydrologic Engineering, 2004-
Editor, Nordic Hydrology 2003-
Editor, Progress in Environmental Science, 1998-2001
Editor, Environment International, 2001-
Reviewer for: Proc. Roy. Soc., Water Resources Research, J. Hydrology, J. Hydrological Processes, Proc. Instn. Civil Engrs., Hydr. Sci. Jnl., etc.

External Examining & Assessment:

Referee: Stockholm Water Prize
Professorial Appointments: Elector, University of Cambridge; University of Tufts, USA, University of Wales, University of Arizona, USA, University of California, Irvine, USA, Trinity College Dublin
Academic Appointments/Promotions: University of Edinburgh, Heriot Watt University, Cranfield University, Technical University of Denmark, Catholic Unive of Leuven, Belgium, University of Khartoum, University of Jordan, University of Riyadh, Khumasi University, Ghana, Institute of Hydrology/Centre for Ecology and Hydrology, Wallingford
DSc: Universities of Bristol, Birmingham
PhD: Universities of Bradford, Bristol, Birmingham, Lancaster, London, Reading, Salford, Southampton, Woollangong (Australia)
External Examiner, University of the West Indies Department of Civil Engineering, 2001-
External Examiner, National University of Ireland, Galway, Departmentof Engineering Hydrology, 2005-
External Examiner, University of Bristol, 2006-
Research Grant Assessment: NERC, EPSRC, MAFF, British Council, Leverhulme Foundation, Royal Society, NOAA (USA), Swiss National Science Foundation, etc.

Overseas Development:

	Overseas lecture courses given include:-
1979-1984	University College, Galway, Eire, International Hydrology MSc course
1982	University of Dar-es-Salaam, ANSTI/UNESCO International Hydrology MSc
1984	Catholic University of Chile, Santiago, Hydrology short course
1986	CETESB, Sao Paulo, Brazil, Hydrology & Water Quality short course
1990	Tsinghua University, Beijing, China, Water Quality lectures
1998	UNESCO Workshop, Amman, Jordan, Wadi Hydrology
2005	Chair and Organiser, G-WADI International Workshop on Hydrological Modelling of Arid and Semi-Arid Areas, Roorkee, India

Recent Invited Lectures:

UNESCO Arab Region, IHP Workshops, Beirut (1999); American Geophysical Union Fall Meeting, San Francisco (1999); Intnl Water & Energy Conference, Las Vegas (2000); Intnl Arid Zone Hydrology Conference, Cairo (2000); Starker Lecturer, Oregon State University (2000); American Geophysical Union Fall Meeting, San Francisco (2002); Kyoto Water Summit (2003).

Principal Areas of Expertise:

Arid zone hydrology and water resource development
Major projects include:- Northern Oman Flood Study (1981) (Principal Investigator) and Five Wadis Study, S.W. Saudi Arabia (1985-88) (Senior Expert) in addition to numerous smaller-scale flood and water resource studies in the Middle East and Africa (Yemen, Jordan, Oman, UAE, Botswana). Published research includes rainfall analysis and simulation, rainfall-runoff modelling, groundwater recharge. Recent research includes sustainable development of alluvial groundwater (Botswana), stochastic spatial-temporal rainfall modelling and rainfall-runoff processes (Arizona). Currently Chair of the UNESCO G-WADI programme, which seeks to disseminate state-of-the-art hydrology and water resources management practice for arid and semi-arid areas.

Rainfall modelling and climate change studies
Stochastic models of rainfall have been developed for various applications with support from NERC and DEFRA. Poisson-process based single site models have been developed for UK and US applications, and are currently being extended for regional UK application in conjunction with continuous simulation rainfall-runoff modelling for flood design and management. A suite of models for spatial rainfall analysis and spatial-temporal simulation has been developed, ranging from radar-based continuous space-continuous time methods to Generalised Linear Modelling of daily rainfall including both temporal and spatial non-stationarity. Applications include modelling impacts of climate variability on flooding in W. Ireland, next-generation rainfall-runoff modelling for UK flood practice, and the representation of climate change scenarios in rainfall models for flood and water resources assessment.

Unsaturated zone and groundwater hydrology
Extensive research is being undertaken into modelling of unsaturated flow and solute transport, and the soil-plant-atmosphere continuum. A major (15 year) research contract with UK Nirex Ltd. involves lysimeter experiments of radionuclide transport in soils and vegetation uptake, and the integrated modelling of these processes for safety assessment of radioactive waste management. 1, 2 and 3D models have been developed;

current research is focussing on redox-dependent geochemical interactions and the representation of uncertainty.

Research in groundwater contaminant transport has included numerical methods for advectively-dominated contaminant transport, field and modelling studies of saline intrusion, field and laboratory studies of non-aqueous phase liquids in groundwater, laboratory and numerical modelling of microbial de-nitrification processes, and modelling of chemically-reactive contaminant transport. A recent EPSRC/BG project has investiged microbial degradation of organic pollutants at a Gas works site and developing models for coupled flow, transport, geochemical interactions and microbial degradation. Other research is developing a framework for uncertainty analysis for well protection zones and investigating the value of data in risk reduction.

Groundwater recharge studies include UK applications and research into surface water/groundwater interactions in ephemeral flow systems, in Saudi Arabia, Oman, Botswana and the USA.

Recent consultancy includes advice to British Nuclear Fuels Ltd. on hydrological, hydrogeological and groundwater modelling studies at the Drigg nuclear repository, Cumbria and a study of Karst groundwater flooding in the Irish Republic. Currently Prof Wheater is a consultant to the State of Nevada concerning safety assessment of a proposed high level nuclear waste repository at Yucca Mountain.

Rainfall-runoff modelling, flood hydrology and urban hydrology
Major flood investigations have been carried out for the Water Research Centre, Severn-Trent Water, Thames Water, the Basque Regional Government, the Oman Government and numerous consultants. Recent UK studies have focussed on urbanisation effects, with respect to a new town development in Hampshire. New point and spatial rainfall modelling methods are being developed for continuous simulation modelling with NERC and MAFF support. A new suite of rainfall-runoff modelling software has been developed with NERC support for regionalisation of rainfall-runoff models, with application to the UK, USA and Southern Africa. A recent study of Karst flooding problems in W. Ireland has included analysis of non-stationarity in rainfall (Southern Water, on behalf of Irish Govt.). Prof. Wheater is currently leading a national programme of research on land use impacts on flooding as part of a £6million EPSRC research programme, co-sponsored by NERC, DEFRA, the EA, Scottish Executive, Northern Ireland Rivers Authority, and research on groundwater flooding under the NERC FREE (Flood Risk from Extreme Events) programme.

Surface water quality
Water quality research overseas has included development of integrated river and lake water quality models for decision support for pollution control in China (EU, in collaboration with Tsinghua University, Beijing and Suez Lyonnaise-des-Eaux), and advice to the Republic of Hungary concerning the water quality impacts of the Gabcikovo-Nagymaros Barrage system. Current UK research funded by NERC and the Environment Agency of England and Wales is focussing on the development of decision support models of nutrients for lowland catchment management, including diffuse and point source loads and in-stream processes. A recent EU contract has developed modelling systems for nutrient response of the Wash catchments in Eastern England, as a pre-pilot study for the EU Water Framework Directive. Research into hydrology and water quality in upland Britain has addressed surface water acidification (Royal Society funding (in collaboration with Norwegian and Swedish Academies of Science) and NERC (Environmental Diagnostics) support). Published research includes field process and modelling studies.

UK water resource management
A major (£10million) national initiative (LOCAR) has been developed to study lowland permeable catchments, including a £2million infrastructure grant to Imperial College. A principle focus is to improve interdisciplinary science to support integrated water resources management of the UK's major aquifers, the Chalk and the Triassic Sandstone Three catchments have been instrumented in detail to monitor hydrological fluxes and water quality, including special instrumentation to investigate aquifer properties and stream-aquifer interactions. A £500k grant from NERC and the Environment Agency is focussing on the development of decision support modelling tools for nutrient management. See also surface water quality, below.

Recent research on water resource systems sponsored by Thames Water has focussed on new methods of assessment of risk and uncertainty in water resources management. This work was awarded the ICE Baker Medal in 2004.

Large-scale hydrological modelling
Research into improved hydrological modelling for global climate models has included new methods for disaggregation of spatial rainfall and evaluation of SVAT schemes at point and catchment scale, contributing to the NERC TIGER programme and the GCIP study of the Mississippi. Current research in collaboration with the Hadley Centre is focussing on improved modelling of climate change impacts over the Nile.

International Consultancies & Research Contracts:

Royal Oman Police & Diwan of HM Sultan Qaboos of Oman; Ministry of Agriculture & Water, Riyadh (as consultant to Dames & Moore); Royal Commission of Jubail, Saudi Arabia; Dar Al Handasah (flood protection of Medinah & Mecca); Howard Humphries (UAE); Balfour Beatty International (Sri Lanka); Maunsells (Oman); Zambian Cons. Copper Mines; CETESB, Sao Paulo (Brazil); Basque Regional Government (Spain); Dar Al Handasah (Yemen); Shimizu Corporation (Japan); European Community (Nepal); JCE (Jordan); Travers Morgan (Oman); Government of Hungary; Southern Water Global (Eire); DANIDA (Botswana); European Union (China); UNESCO; Republic of Argentina.

UK Consultancies and Research Contracts:

Anglian Water Authority, Severn Trent Water Authority, Thames Water Authority, Royal Society, UK Nirex Ltd., British Nuclear Fuels Ltd., Balfours, W.S. Atkins, Watson Hawksley, Hydro-logic Ltd., Electrowatt, Her Majesty's Inspectorate of Pollution, Eagle Star Property Management, Natural Environment Research Council, Binnie and Partners, Thames Water Utilities Ltd, EPSRC, Halcrow, Environment Agency, Department of Environment, Food and Rural Affairs.

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ATTACHMENT B

Contentions Adopted By **Howard S. Wheater** In Accordance With Affidavit
NEV-SAFETY-14
NEV-SAFETY-15
NEV-SAFETY-16
NEV-SAFETY-17
NEV-SAFETY-18
NEV-SAFETY-20
NEV-SAFETY-21
NEV-SAFETY-22
NEV-SAFETY-23
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NEV-SAFETY-36
NEV-SAFETY-37
NEV-SAFETY-38
NEV-SAFETY-39
NEV-SAFETY-40
NEV-SAFETY-45
NEV-SAFETY-46
NEV-SAFETY-47

Attachment 14

Affidavit of James A. McMaster

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF JAMES A. MCMASTER

I, James A. McMaster, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is James A. McMaster, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

James A. McMaster

The above-named affiant personally appeared before me this 11 day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: 2011

ERICA L LONGTIN
01L06177259
Notary Public, State of New York
Qualified in WASHINGTON County
My commission expires NOVEMBER 13th, 2011

ATTACHMENT A

CURRICULUM VITAE

JAMES A. MCMASTER

James A. McMaster
5483 Bluff Head Road, P. O. Box 7
Huletts Landing, New York 12841
Tel: 518-499-0331 Cell: 518-879-5473 Fax: 518-499-0331
E-mail: jimmcmaster@msn.com

EDUCATION: The Ohio State University, Columbus, Ohio; 1966, Bachelor of Welding Engineering (5 years)

Harvard Business School, Cambridge, Massachusetts; 1977, Program for Management Development - PMD 33 (14 weeks)

EXPERIENCE:

9/97-Present MC Consulting Titanium application and business development. Focus on titanium metal technical application, specifications and standards, technology, welding and manufacturing, and market development. Providing concept design, estimating, sales support, project management, procurement support, and manufacturing support for titanium users and fabricators. Active in ASTM, AWS, ASME, and SAE-AMS. Member ASTM B10, ASME Boiler Code Committees. Obtained ASME Code approval for Grades 26/27/28/38 and Ti 0.8Ni-0.3Mo-0.1Ru (industrial sponsors), Code Case for parallel plate explosion welding. Instrumental in developing technical changes leading to revision of AWS A5.16-04 and 07. Instrumental in development of four new higher strength unalloyed grades in ASTM Specifications, various revisions leading to 2008 changes. Developed and presented titanium welding course for engineers. Active in developments for titanium clad to improve on batten strip welding for clad pressure vessels as well as ignition resistance in oxygen environments. Providing welding and manufacturing support for titanium alloy hull for 6500 meter depth research submersible, application of new high strength alloys to mine resistant military vehicles.

(Titanium Industries acquired by Kamyr, Inc., in September 1980. Transferred to Kamyr in 1981. Kamyr, Inc., acquired by Ahlstrom Corporation in February 1990. Aquaflow sold to U. S. Filter in September 1997.)

4/93 - 9/97 Ahlstrom Aquaflow, Division of Kamtech, Inc., then Ahlstrom Machinery Inc. Managing Director. Starting from no business in North America, built Aquaflow pulp and paper mill effluent treatment system business unit, successfully and profitably completing several major effluent treatment system projects in North and South America on an Engineer, Procure, Construct basis.

4/91 - 4/93 Ahlstrom-Kamyr, Inc, Glens Falls, New York
Developed international procurement sources and licensee network to support worldwide marketing of pulp mill equipment and systems. Developed program for technology transfer among workshops in the Ahlstrom (Finland) and Kamyr (North America) groups of companies.

10/87 - 4/91 Kamyr, Inc., Glens Falls, New York
Manager, Mineral Processing. Developed existing R&D program in gold leaching technology. Established international marketing effort. Involved in construction and responsible for start up of demonstration scale counter-current tower gold leaching process in South Africa. Project abandoned due to falling gold prices.

12/83 - 9/87 Kamtech, Inc. Glens Falls, New York
Manager, Marketing and Engineering. Expanded construction market beyond parent company's mechanical installations to complete turnkey construction of major pulp mill facilities. Obtained first major orders for lime kiln mechanical construction, major recovery boiler rebuilds, and paper machine wet end rebuild, each representing a new field for the company. Established engineering function and set up quality control program to meet requirements of ASME U, S, A, and PP stamps and National Board R stamp.

7/81-12/83 Kamyr, Inc., Glens Falls, New York
Staff consultant on materials, design, field welding, and failure analysis problems. Established formal quality assurance program. Implemented titanium pipe welding and digester weld overlay programs within subsidiary construction companies.

4/72 - 6/81 Titanium Industries, Fairfield, New Jersey
Corporate cofounder (1972). Established corporate strategy/policy based on high quality standards that was significantly responsible for company growth and direction. Chief Engineer (1972-74). Set up engineering and quality control functions. Qualified company for ASME Code work. Elected Vice President (1974). Vice President, Engineering (1978-81). Directed all engineering activities, major project sales, and new product development. Vice President, Operations (1976-78). Implemented new systems to simplify and improve manufacturing including inventory planning, parts control, job costing, and reporting. Directed overall operation of engineering, manufacturing, and warehouse operations. Revenue grew to over $33 million from 1972 to 1981.

11/69 - 3/72 Titanium Metals Corporation, West Caldwell, N.J.
Manager, Commercial Research. Market research and forecasting for aerospace and industrial markets. Industrial Market Development Engineer. Successful programs in establishing titanium tubing in petroleum refining, industrial plate products, pulp and paper applications.

7/66 - 9-69 General Dynamics Corporation, Electric Boat Division, Groton, Connecticut
Welding Engineer. Developed titanium welding technology for research submersibles. Metallurgical Engineer, ship component failure analysis, material and manufacturing liaison for advanced projects group.

1965 - 66 F.W. Bell, Inc., Columbus, Ohio
Lab technician. Magnetic sensing devices.

1964 Summer Dravo Corporation, Pittsburgh, Pennsylvania
Engineering aide. Inland shipyard.

Miscellaneous: Forty two published papers and presentations to national technical societies. Guest lecturer at Liberty Bell Corrosion Course, and Titanium Design course, Philadelphia (4 years). International business experience in Europe, Scandinavia, Brazil, Argentina, and Chile, South Africa, Mexico, Japan, Australia.

ATTACHMENT B

Contentions Adopted By **James A. McMaster** In Accordance With Affidavit
NEV-SAFETY-80
NEV-SAFETY-81
NEV-SAFETY-82
NEV-SAFETY-83
NEV-SAFETY-84
NEV-SAFETY-85
NEV-SAFETY-124
NEV-SAFETY-125
NEV-SAFETY-126
NEV-SAFETY-127
NEV-SAFETY-128
NEV-SAFETY-129
NEV-SAFETY-130
NEV-SAFETY-142
NEV-SAFETY-143
NEV-SAFETY-144
NEV-SAFETY-145

Attachment 15

Affidavit of Jonathan Overpeck

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of U.S. DEPARTMENT OF ENERGY License Application to Construct a Geologic Repository at Yucca Mountain	))))))))	Docket No. 63-001

AFFIDAVIT OF JONATHAN OVERPECK

I, Jonathan Overpeck, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Jonathan Overpeck, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Jonathan Overpeck

The above-named affiant personally appeared before me this 12 day of December, 2008, and executed this affidavit.

Connie J. Huber
Notary Public

My Commission expires: April 24, 2010

Connie J. Huber
Notary Public - Arizona
Pima County
My Commission Expires
April 24, 2010

ATTACHMENT A

CURRICULUM VITAE

JONATHAN OVERPECK

JONATHAN TAYLOR OVERPECK
CURRICULUM VITAE

ADDRESSES

Work:
Institute for Environment and Society (IES)
University of Arizona
715 N. Park Ave., 2nd Floor
Tucson, AZ 85721
Telephone: (520) 622-9065
Email: jto@u.arizona.edu

Home:
5230 N. Via Condesa
Tucson, AZ 85718
Telephone: (520) 615-3633

PERSONAL: Born June 29, 1957 in Iowa, USA.

EDUCATION

December 1985 – Ph.D. in Geological Sciences, Brown University, Rhode Island
June 1981 – MSc in Geological Sciences, Brown University
June 1979 – AB in Geology (Honors), Hamilton College, New York
Summer 1978 – Geologic Field Mapping in Montana, Indiana University

HONORS

2008 – NOAA Oceanic and Atmospheric Research Outstanding Scientific Paper Award
2007 – Nobel Peace Prize – shared for role as a Coordinating Lead Author of the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC).
2007 – Shared winner of Atmospheric Science Librarians International's Scientific and Technical Category for "high impact comprehensive publication" for *Climate Change 2007: The Physical Science Basis.*
2005 – Bjerknes Lecturer, American Geophysical Union
2005 – John Simon Guggenheim Fellowship Award
2004 – Birbal Shani Institute of Palaeobotany, Lucknow, India Prof. T.M. Harris Medal for 2004 (awarded for best Indian co-authored paper in field in 2004)
2001 – American Meteorological Society's Walter Orr Roberts 2001 Award
1999 – US Department of Commerce Gold Medal
1996 – US Department of Commerce Outstanding Performance Award
1995 – National Geophysical Data Center Director Award
1994 – US Department of Commerce Bronze Medal
1992 – US Department of Commerce Outstanding Performance Award
1991 – US Department of Commerce Unusually Outstanding Performance Award
1979 – Sigma Xi
1978 – Hamilton College Senior Fellowship

PROFESSIONAL APPOINTMENTS

2008-present – Founding *Co-Director*, Institute for Environment and Society, Univ. of Arizona, Tucson
2006-present – *Director*, UA Translational Environmental Research Program and associated UA Technology and Research Initiative Fund (TRIF).
2006-present – *Affiliated Faculty Member* – James E. Rogers College of Law, Univ. of Arizona, Tucson
2004-present – *Joint Professor*, Dept. of Atmospheric Sciences, Univ. of Arizona, Tucson
1999-2008 – *Director*, Institute For Study of Planet Earth, Univ. of Arizona, Tucson
1999-present – *Professor*, Dept. of Geosciences, Univ. of Arizona, Tucson
1992-00 – *Adj. Assoc. Professor*, Dept. of Geological Sciences, University of Colorado
1990-9 – *Fellow,* Institute for Arctic and Alpine Research, Univ. of Colorado
1992-9 – *Director (and Founder)*, World Data Center for Paleoclimatogy, Boulder, Colorado
1990-9 – *Head (and Founder),* NOAA Paleoclimatology Program, NGDC, Boulder
1991-7 – *Adjunct Research Scientist,* Lamont-Doherty Geological Observatory,
1986-90 – *Associate Research Scientist,* Lamont-Doherty Geological Observatory
1985-86 – *Post-doctoral Res. Scientist,* Lamont-Doherty Geological Observatory
1985 – *Teaching Fellow,* Stratigraphy and Sedimentation*,* Brown University
1980-84 – *Research Assistant,* Brown University
1979 – *Teaching Assistant,* Mineralogy, Brown University
1979 – *Geologist,* U.S. Geological Survey, Menlo Park, California
1977 – *Field Assistant,* AMAX Exploration, Helena, Montana

PRIVATE-SECTOR PARTNERSHIPS and TECH TRANSFER

2006 – present – Climate Appraisal Services LLC – lead science partner
2006 – Competed Options Agreement, as well as Technical Information License Agreement, between *Climate Appraisal Services* and The Arizona Board of Regents on behalf of The University of Arizona
2006 – Launched *Climate Appraisal Services LLC* at *ClimateAppraisal.com* – the first address-based service for climate and environmental risks.

GRANT AWARDS (Not including NOAA 1991-99)

2008 – Qatar Foundation. *The Qatari Initiative for Solar Power and Desalinization* A proposed partnership with the University of Arizona submitted by invitation (Co-PI with 4 others).
2008-2013 – NSF "IGERT: Landscape Change: Interactions between biological processes, physical processes, and people" – 5 years – $3,092,812 (CO-PI With 4 others). *Pending*.
2008-2013 – NOAA "Abrupt Climate Change Dynamics and Impacts: Increasing Societal Resilience to Future Climate Change" – 5 years – $9,986,678 (PI with 4 Co-PIs). *Pending*.
2007-2008 – NOAA "Reconciling Projections of Future Colorado River Stream Flow" – 1 year – $250,000 (Co-PI with 7 others at several institutions)

2007-2012 – NOAA “Integrating Climate Science for Decision-Support, Mitigating Risk and Promoting Resilience” – 5 years – $4,899,080 (PI with 8 other UA Co-PIs)
2007-2009 – NOAA “Variability in the Eastern Equatorial Pacific Climate, ENSO and North American Drought Impacts over the last 2000 years” – 2 years – $96,832 (UA component; Overpeck is project PI of overall project)
2006-2009 – NSF “Collaborative Research: High-resolution, Low-Latitude Paleoclimatology From Newly Acquired Sediment Drill Cores from Lake Bosumtwi, Ghana” – 3 years – $244,687 (UA component)
2006-2008 – NSF “Paleoclimatic Change, Landscape Evolution, and Cultural transformations in Far Western Tibet, 2500 BP-present” – 3 years – $725,789 (Co-PI with 5 others, including Prof. Jon Pelletier).
2005-2009 – NSF “Collaborative Research: A Synthesis of the Last 2000 Years of Climatic Variability from Arctic Lakes” – 4 years – $1.85M (Co-PI with 12 others).
2004-2005 – NSF "Collaborative Research: High-Resolution, Low-Latitude Paleoclimatology Through Scientific Drilling of Lake Bosumtwi, Ghana," – 1.5 years. $677,889 (Co-PI with three others).
2004-2006 – NSF “Management of Ecosystems in the US Southwest and Related Areas of Northern Mexico in the Context of Complex Uncertainties” – 1 year – $77,500 (Decision making under uncertainty planning proposal, Co-PI with 4 others).
2003-2005 – NSF “Acquisition of an analytical facility for high-resolution paleoclimatology” – 3 years – $339,915 (Co-PI with 4 others).
2002-2005 – ARCUS “ARCSS Committee Chair Support” – 3 years – $54,000/year (PI)
2002-2006 – NSF “ITR: Development of an enhanced computer assisted analysis system for earth science: investigation of laminated sediments and tree rings” – 3 years – $436,480 (PI with 2 others).
2002-2004 – NSF “Varved Records of Decade- to Century-Scale Climate Variability in the Tropical Atlantic Sector” – 2 years – $167,000 (PI with 1 other).
2002-2004 – NSF “Scientific Drilling at the Bosumtwi Impact Structure, Ghana, West Africa” – approx. 3 years – $1,200,000 (CoPI with 3 others).
2002-2007 – NOAA “Climate Assessment for the Southwest Project (CLIMAS)” – 5 years – $5,437,806 (PI with 12 others).
2000-2003 – EPA “Climate and human contributions to fire affecting ecosystems in the U.S. Southwest” – 3 years – $1,260,993 (Co-PI with 5 others)
2000-2005 – Multiagency “Desert Southwest Cooperative Ecosystem Study Unit (DS-CESU) – cooperative agreement – no set award amount (multiple CoPI’s)
2000-2002 – National Science Foundation Grant ATM “Century-scale variability in the Asian southwest Monsoon” 2-years – $119,402 (PI with J.Cole)
1998 to 2001 – National Science Foundation Grant ATM-98100254 “Lake Bosumtwi, Ghana: High-resolution paleoclimatology and seismic reflection site survey” 3-years – $518,944 (PI with C. Scholz)
1997 to 2000 – National Science Foundation Grant ATM-97 “Radiocarbon, Ocean and Climate Changes over the Last Deglaciation” 3-years – $300,000 (Co-PI with K. Hughen and S. Lehman)

1997 to 2001 – National Science Foundation Grant ATM-PALE 9709918 " Labrador Sea variability over decade to millennial time-scales" 4-years – $564,000 (PI with G. Miller)

1997 to 2000 – NASA Grant LCLUC-0003: Assessing Future Stability of U.S. High Plains Landcover: Integration of Process Modeling with Landsat, In Situ Modern and Paleoclimate Data" 3 years – $530,000 (PI with 4 Co-PIs)

1996 to 1999 – National Science Foundation Grant ATM-9631282: "Climatic Change of the Last 500 Years: Simulations versus Data" 3 years – $270,000 (PI)

1995 to 1997 – NASA Graduate Student Fellowship in Global Change Research: "A 14,000 Year Record of Decade- to Century-scale Tropical Climate Variability from Annually-laminated Sediments of the Cariaco Basin, Venezuela" 2 years – $44,000 (funds graduate student Konrad Hughen).

1995 to 1997 – National Science Foundation Grant OCE-9521058: "Interannual to Century-scale Variability in the Tropical Caribbean/ Western Atlantic: Varve-based Reconstructions from the Anoxic Cariaco Basin" 2 years – $52,000 (PI).

1994 to 1997 – National Science Foundation Grant ATM94-02657: "A PALE Lake Sediment Calibration Network for the Eastern Canadian Arctic" 3 years – $350,000 (PI with G. Miller).

1993 to 1996 – National Science Foundation Grant ATM-930072: "Eastern Arctic Climate of the Past 2,000 years: The Lake Sediment Record." 3 years – $262,000 (PI with R. Anderson).

1991 to 1994 – National Science Foundation Grant ATM-9006307: "Project ARRCC – Analysis of Rapid and Recent Climatic Change." 3 years – $720,000 (PI with 5 others).

1991 to 1994 – National Science Foundation Grant ATM-9019023: "Paleoecologic Tests of Climate Model Simulations for the Past 18,000 Years in Eastern North America." 3 years – $170,000 (Co-PI with S. Jackson).

1991 to 1993 – National Science Foundation Grant OCE91-15923: "Interannual- to Millennial-scale Environmental Variability as Recorded in the Laminated Sediments of the Cariaco Basin, Venezuela: Late Quaternary to Present." 2 years – $200,000 (PI with L. Peterson).

1990 to 1992 – National Science Foundation Grant DPP90-00371: "High-resolution Holocene Climatic Reconstructions from the Eastern Canadian Arctic." 3 years – $216,000 (PI).

1989 to 1991 – NOAA: "Project ARRCC – Analysis of Rapid and Recent Climatic Change." 2 years – $121,217 (PI with David Rind).

1990 to 1992 – National Science Foundation Grant OCE89-11484: "High-resolution Paleoenvironmental Study of the Cariaco Basin, Venezuela: Late Quaternary to Present." 2 years – $477,000 (PI with L. Peterson and D. Murray).

1989 – C.N.R.S. Laboratory Travel Award for study in France- 10,000 FF (Recipient).

1989 to 1991 – EPA Grant: "Modeling Future Climate and Vegetation Change." Awarded through NASA/GISS, 3 years – $200,000 (PI).

1988 to 1990 – National Science Foundation Grant ATM88-15506: "Century to Millennium-scale Variability of the Indian Monsoon over the Past 40,000 years." 2 years – $170,000 (PI).

1988 to 1989 – National Science Foundation Grant DPP88-00749: "High-resolution Paleoclimatic Time Series from Annually Laminated Lake Sediments: Baffin Island and Northern Labrador." 1 year – $64,617 (PI with G. Jacoby).

1987 to 1988 – EPA Grant: "Assessing the Response of Vegetation to Future Trace-Gas-Induced Climate Change: The Application of Ecological Response Surfaces." Awarded through NASA/GISS, 1 year – $50,000 (PI with P. Bartlein).

1987 – Subcontracts, EPA Contract to Columbia University and NASA Goddard Institute for Space Studies (J. Hansen, R. Levenson, and C. Chu, principal investigators): "Global Climate Model Development and Sensitivity Experiments." 1 year – $20,000 and $10,000.

1986 to 1988 – National Science Foundation Grant ATM86-12376: "Precisely Dated Time Series and the Synoptic Climatology of the Past 12,500 years in Eastern North America." 2 years – $148,580 (PI with G. Jacoby).

POST-DOCTORAL SUPERVISION

2002 to 2003 – Dr. Nan Schmidt
1997 to 1998 – Dr. Connie Woodhouse
1996 to 1997 – Dr. Elsa Cortijo
1995 to 1996 – Dr. Terri King

GRADUATE STUDENT SUPERVISION

Sarah Trube (PhD)	2008 to present	Univ. of Arizona – GEO (Co-Advisor)
Sarah White (MS)	2008 to present	Univ. of Arizona – GEO (Advisor)
Nicholas McKay (PhD)	2007 to present	Univ. of Arizona – GEO (Advisor)
Cody Routson (PhD)	2007 to present	Univ. of Arizona – GEO (Advisor)
Jessica Conroy (PhD)	2003 to present	Univ. of Arizona – GEO (Advisor)
Toby Ault (PhD)	2005 to present	Univ. of Arizona – GEO (Comm. Mem.)
Adam Csank	2007 to present	Univ. of Arizona – GEO (Comm. Mem.)
Jennifer Rice (PhD)	2006 to present	Univ. of Arizona – GRD (Comm. Mem.)
Rachael Novak (MS)	2005 to present	Univ. of Arizona – GEO (Advisor)
Sephanie McAfee (PhD)	2005 to present	Univ. of Arizona – GEO (Co-Advisor)
Anna Felton (MS)	2005 to 2006	Univ. of Arizona – GEO (Comm. Mem.)
Toby Ault (MS)	2005 to 2006	Univ. of Arizona – GEO (Comm. Mem.)
Kevin Anchukaitis (PhD)	2004 to 2007	Univ. of Arizona – GEO (Comm. Mem.)
Scott St. George (PhD)	2004 to present	Univ. of Arizona – GEO (Comm. Mem.)
Jessica Conroy (MS)	2003 to 2006	Univ. of Arizona – GEO (Advisor)
Allison Drake (MS)	2003 to 2005	Univ. of Arizona – GEO (Advisor)
Thomas Damassa (MS)	2002 to 2005	Univ. of Arizona – GEO (Comm. Mem.)
David Brown (PhD)	2002 to 2004	Univ. of Arizona – GRD (Comm. Mem.)
John Burkhart (PhD)	2002 to 2005	Univ. of Arizona – HWR (Comm. Mem.)
Cristina Luiz (MS)	2001 to 2004	Univ. of Arizona – GEO (Comm. Mem.)
Jim Morrison (PhD)	2003 to 2004	Univ. of Arizona – GEO (Advisor)
Camille Holmgren (PhD)	2001 to 2005	Univ. of Arizona – GEO (Comm. Mem.)

Jennifer Miller (PhD)	2001 to 2006	Univ. of Arizona – GEO (Comm. Mem.)
Katherine Likos (MS)	2000 to 2002	Univ. of Arizona – GEO (Advisor)
Tim Shanahan (PhD)	2000 to 2001	Univ. of Arizona – HWR (Comm. Mem.)
	2002 to 2006	Univ. of Arizona – GEO (Advisor)
Simone Alin (PhD)	2000 to 2002	Univ. of Arizona – GEO (Comm. Mem.)
Carrie Morrill (PhD)	1998 to 1999	Univ. of Arizona – GEO (Co-Advisor)
Carrie Morrill (PhD)	1998 to 1999	Univ. of Colorado (Co-Advisor)
Noah Daniels (MS)	1998 to 1999	Univ. of Colorado (Co-Advisor)
Mary Davis (PhD)	1998 to 2002	Ohio State Univ. (Committee Member)
Alex Robertson (MS)	1996 to 2000	University of Colorado (Advisor)
Jorunn Hardardottir (PhD)	1996 to 1999	Univ. of Colorado (Committee Member)
Frank Urban (MS)	1996 to 1999	Univ. of Colorado (Co-Advisor)
Ulrike Huber (PhD)	1996 to 1999	Univ. of Colorado (Committee Member)
Nathalie Smith (MS)	1996 to 1997	Univ. of Colorado (Committee Member)
Jennifer Mengan (PhD)	1996 to 2001	Univ. of Colorado (Co-Advisor, Comm. Mem)
Mike Kerwin (PhD)	1995 to 2000	University of Colorado (Advisor)
David Gorodetsky (MS)	1995 to 1996	Univ. of Colorado (Committee Member)
Lisa Doner (PhD)	1994 to 2000	Univ. of Colorado (Committee Member)
Konrad Hughen (PhD)	1992 to 1997	University of Colorado (Advisor)
Jay Moore (MS)	1995 to 1996	Univ. of Colorado (Committee Member)
Peter Sauer (PhD)	1993 to 1997	Univ. of Colorado (Committee Member)
Regina Figge (PhD)	1992 to 1996	Univ. of Colorado (Committee Member)
Lisa Barlow (PhD)	1992 to 1994	Univ. of Colorado (Committee Member)
Lysanna Anderson (PhD)	1991 to 1997	Univ. of Colorado (Committee Member)
Colin Price (PhD)	1990 to 1992	Columbia Univ. (Committee Member)

COURSES TAUGHT

2009	*Western North American Drought Seminar,* The University of Arizona
2005-present	*Fundementals of Past Climate Dynamics* – New graduate-level, The University of Arizona
2003	*Paleoclimate Seminar,* The University of Arizona
2002-present	*Paleoclimate Seminar,* The University of Arizona
2001-2003	*Life on Earth (included honors section),* the University of Arizona
2001	*Paleoclimate Dynamics (North Atlantic Variability),* the University of Arizona
2000	*Life on Earth (new course for non-science freshmen and sophomores),* the Univ. of Arizona
2000	*Paleoclimate Dynamics (African and Asian Monsoons),* the University of Arizona
1996	*Introduction to Climate System Modeling* at The University of Colorado, Boulder – Independent Study for three students. Co-taught with R. Webb
1994	*Methods of Quantitative Paleoenvironmental Reconstruction and Time* spring *Series Analysis* at the Univ. of Colorado, Boulder – graduate seminar. Co-taught with R. Webb and D. Anderson
1985	*Stratigraphy and Sedimentation* at Brown University. Included leading spring a 10-day trip to study carbonate environments in South Florida

SUPERVISON/MANAGEMENT TRAINING EXPERIENCE

2002 – Completed “Human Subjects” Training/Certification
1997 – NOAA Workshop for People with Disabilities
1996 – US Gov’t Senior Executive Service Approved Course:
“The Aspen Institute Executive Seminar for the Public Sector”
1995 – Department of Commerce Approved Management Course:
"Merit System Principles: Understanding and Applying Them"
1995 – Department of Commerce Approved Diversity Management Course: “Conflict Resolution”
1994 – Department of Commerce Approved Management Course:
"Improving Your Listening and Communication Skills"
1992 – Department of Commerce Approved Management Course: "Equal Employment Opportunity Training for Supervisors and Managers."
1992 – Department of Commerce Approved Management Course: "People Skills for Supervisors and Managers"

SERVICE ON UNIVERSITY COMMITTEES

2008 to present – Member, Vice President for Research Advisory Council for Strategic Advancement
2008 – Member, Provost’s Advisory Council for Strategic Advancement
2007 to present – The University of Arizona president’s point person for the American College and University Presidents Climate Commitment
2007 to present – Member, Biosphere 2 Advisory Board.
2006 to present – UA Translational Environmental Research Faculty Advisory Committee (member and chair).
2005 to 2006 Academic Year: on sabbatical, San Juan Mountains, Colorado
2005 to present – University of Arizona advisory committee for the UA NSF AMS Facility
2004 – University of Arizona representative to the Arizona governor’s tri-university water sustainability planning group
2003 to 2005 – Member, Provost Focused Excellence Study Team for “Earth Science and Environmental Programs”
2003 to 2005 – Member, Executive Committee, University of Arizona -USGS Earth Surface Processes Research Institute (ESPRI)
2003 UA-USGS ESPRI Council of Advisors
2002 to 2003 – Co-Chair, UA Flandrau Science Center’s Science and Technology Working Group (to provide science and technology input in the planning and development of a new 100,000 sq. ft. science center for the University of Arizona)
2002 – Member, Biosphere2 Center Research Advisory Board, Columbia University
2002 – Member, External Review Committee, University of New Mexico, Center for Advanced Studies
2001 to present – University of Arizona Representative to US Council of Environmental Deans and Directors

2001 – Chair, UA Institute for the Study of Planet Earth Program Review Self-Study Committee
2001 to 2002 – Member, UA Dean Search Comm., College of Social and Behavioral Sciences
2000 – UA Udall Fellowship Selection Committee
2000-2002 – Member of University of New Mexico Center for Advance Studies External Advisory Panel
2000 to 2001 – University of Arizona Campaign Water Committee
2000 – Member, Lab. for Tree Ring Res. Faculty Search Comm, Univ. Arizona
2000 to 2001 – Member and Co-Chair, Dept. of Atmos. Sci. Faculty Search Committee, Univ. Arizona
2000 to 2001 – College of Science rep. for Prop. 301 Water Initiative, Univ. Arizona
2000 – Promotion and Tenure Committee, Dept. Geosci., Univ. Arizona
2000 to present – Member, Global Change PhD Minor Faculty
1999 to 2000 – Self-Study Future Directions Committee, Dept. Geosci., Univ. Arizona
1996 to 1997 – Strategic Plan Committee, INSTAAR, University of Colorado
1995 to 1996 – Research & Uniqueness & Funding Committee, INSTAAR, University of Colorado
1993 to 1995 – Executive Committee, INSTAAR, University of Colorado
1992 to 1997 – Future Funding Committee, INSTAAR, University of Colorado
1992 to 1998 – Computer Committee, INSTAAR, University of Colorado

SERVICE ON NATIONAL and INTERNATIONAL SCIENCE and EDUCATION COMMITTEES

2008 to present – member, U.S. National Academy of Science, Committee on Ecological Impacts of Climate Change
2008 to present – member, Federal Advisory Committee focused on “Climate change and the United States: Analysis of the effects and projections for the future – Unified Synthesis Product”
2008 to present – Member, University Corporation for Atmospheric Research Membership Committee
2007 – Member, U.S. National Science Foundation advisory panel for the FY 2007 Human and Social Dynamics competition. Washington, DC.
2006 to 2007 – Member, Committee charged with drafting society’s new Statement on Climate Change Impact, American Meteorological Society
2004 to 2006 – Member, American Geophysical Union Global Environmental Change Executive Committee
2002 to 2005 – Member, Board on Higher Education, American Meteorological Society
2004 to 2007 – Convening Lead Author, Working Group 1, Chapter 6 (Paleoclimatology) UN/WMO Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment. Also, Lead Author for the Technical Summary, and also Lead Author for the Summary for Policy Makers.
2004 to 2005 – Member, Subcommittee for Global Change Research of the Department of Energy's Biological and Environment Research Committee (BERAC)
2003 to 2005 – Member, NOAA Ad Hoc Group on Paleoclimatology

2003 to present – Member, NOAA Climate Working Group – formally the NOAA Climate and Global Change Working Group (also on Executive Committee of the latter)
2002 to 2007 – Chair/Member, NSF Arctic System Science (ARCSS) Committee (Chair to 2006)
2001 to 2003 – member, U.S. National Academy of Science, Committee on Coping with Increasing Demands on Government Data Centers
2000 to 2003 – member, U.S. National Academy of Science, Committee on Abrupt Climate Change: Science and Policy
1999 to 2004 – Co-chair (with M. Cane), US PAGES/CLIVAR Working Group
1999 to 2002 – member, NSF Study of Environmental Arctic Change (SEARCH) Steering Committee
1998 to 2008 – member, NSF Arctic System Science (ARCSS) Committee
1997 to 2003 – member, U.S. National Research Council National Committee for International Quaternary Association (INQUA)
1997 to 1999 – member, Ocean Drilling Program (ODP) Science Committee (SCICOM)
1995 to 2002 – Co-Chair (with J-C Duplessy), IGBP PAGES-WCRP CLIVAR Working Group
1994 to 1998 – member, Arctic System Science Data Management Working Group
1994 to 1999 – member, Steering Committee, US/NSF Earth System History Research Initiative
1993 to 1999 – member of IGBP PAGES (Past Global Changes) Scientific Steering (SSC) and Executive Committees, Vice Chairman SSC 1998-99.
1993 to 1999 – member, IGBP DIS (Data and Information System) Scientific Standing Committee
1991 to 1998 – member, Steering Committee, "Paleoclimate of Arctic Lakes and Estuaries (PALE)," NSF Sponsored research initiative with broad international participation.

NATIONAL AND INTERNATIONAL WORKSHOPS CONVENED

June, 2008 – PAGES/CLIVAR workshop "Reducing and representing uncertainties in high-resolution proxy climate data," Treste, Italy (member, organizing committee)
May, 2008 – NOAA RISA National Climate Service Visioning Workshop, Denver, CO (member, organizing committee)
October, 2006 – Climate Variability & Change in the San Juan Mountains: A Scientist-Stakeholder Dialogue, Durango CO (member, organizing committee)
July, 2006 – Retreat of the NOAA Climate Working Group focused on improving NOAA's ability to provide the nation with drought information, Santa Fe, NM (member, organizing committee).
May, 2006 – Workshop focused on methodologies for improved analysis of laminated lake and marine sediments, Tucson, AZ (Organizer and host)
May, 2006 – Workshop focused on Arctic climate variability and change over the last 2000 years (co-organizer and host). Tucson, AZ
May, 2005 – Second Sustainability Under Uncertainties in Arid and Semiarid Ecosystems workshop, Tucson, AZ (member, organizing committee).
January, 2005 – First Sustainability Under Uncertainties in Arid and Semiarid Ecosystems workshop, Tucson, AZ (member, organizing committee).
August, 2004 – Second NSF Retreat on Arctic System Science Synthesis, Lake Tahoe (lead convener with others on NSF Arctic System Science Committee).

June, 2004, 1st International CLIVAR Science Conference, Baltimore, Maryland (member, organizing committee).

February, 2004, NOAA Workshop "Enhancing Decision-making Through Integrated Climate Research: Alaska." Anchorage, Alaska (member, organizing committee).

November, 2003 – CLIVAR/PAGES/IPCC Workshop: A multi-millennia perspective on drought and implications for the future, Tucson, AZ (co-convened with K. Trenberth).

August, 2003 – NSF Retreat on Arctic System Science Synthesis, Big Sky, MT (lead convener with others on NSF Arctic System Science Committee).

March, 2003 – International Limnogeology Congress, Tucson AZ (organizing committee).

May, 2002 – NRC Workshop on copping with Increasing Demands on Government Data Centers, Austin, TX (co-convened with several others on NRC Committee).

September, 2001 – International Continental Drilling Programme Workshop on Scientific Drilling at the Lake Bosumtwi Impact Structure, Potsdam, Germany (co-convened with C. Koeberl, B. Milkereit, and C. Scholz).

June, 2001 – NOAA funded workshop: International Workshop on Applications and Human Dimensions of Monsoon Research, Tucson, AZ (co-convened with B. Morehouse, A. Ray, and R. Webb).

March, 2001 – NOAA and USDA funded Fire and Climate in the Southwest 2001, Tucson, AZ (co-convened with four others).

February, 2001 – NOAA and USDA funded Fire and Climate 2001, Tucson, AZ (co-convened with four others).

October, 2000 – IGBP PAGES Workshop: High-Resolution Climate Variability of the Holocene, Avignon, France (co-convened with K. Briffa, D. Raynaud, J-. Duplessy and R. Bradley).

September, 2000 – NRC Abrupt Climate Change: Science and Policy Workshop, Palisades, NY (co-organized with R. Alley et al.).

November, 1999 – Joint WCRP-IGBP PAGES-CLIVAR Workshop on "Climate Variations of the Last 300 to 1000 Years", Venice, Italy (co-convened with J-C. Duplessy).

June, 1999 – NOAA/NASA Workshop: Assessing the full range of central North America Droughts and Associated Landcover Change, Boulder, Colorado (co-convened with R. Webb and C. Woodhouse)

January, 1999 – Joint WCRP-IGBP PAGES-CLIVAR Data Management Workshop, Boulder, CO (co-convened with R. Webb and D. Anderson).

April, 1998 – IGBP PAGES (Past Global Changes) First Open Science Meeting, London, England (Co-organized with 5 other).

April, 1997 – Joint IGBP-World Data Center sponsored workshop on meeting the scientific data management needs of the IGBP, Boulder (co-organized with G. Szejwach)

September, 1996 – Joint CLIVAR (World Climate Research Program)-PAGES (International Geosphere Biosphere Program) sponsored "PAGES-CLIVAR Working Group" workshop on climate variability and predictability, Villefrance, France (co-convened with J-C. Duplessy)

March. 1996 – NSF sponsored Earth System History Workshop "Geologic records of terrestrial processes and systems," Portland OR (co-organized with P. Olsen, N. Pisias and T. Webb III).

November, 1994 – Joint CLIVAR (World Climate Research Program)-PAGES (International Geosphere Biosphere Program) sponsored workshop on climate variability and predictability, Venice Italy (co-convened with J-C. Duplessy)

August, 1993 – IGBP PAGES Sponsored "Global Paleoenvironmental Data," Bern Switzerland (co-convened with J. Pilcher).

January 1988 – NSF sponsored meeting of the Coordination Group for "The global reconstruction and modeling of interannual, decadal, and century-scale climate variability," New York (co-convened with G. Jacoby).

SYMPOSIA and SPECIAL SESSIONS CONVENED

December, 2003 – “The Last Interglacial” 2003 Fall Meeting of the American Geophysical Union, San Francisco (co-convened with G. Miller and B. Otto-Bleisner).

December, 1997 – "Tropical Ocean and Climate Records From the Anoxic Cariaco Basin” 1997 Fall Meeting of the American Geophysical Union, San Francisco (co-organized with L. Peterson and F. Muller-Karger)

December, 1995 – "Abrupt Climatic Change During the Current Interglacial” 1995 Fall Meeting of the American Geophysical Union, San Francisco (co-organized with L. Keigwin)

October, 1992 – "WDC/IGBP Paleoclimate Data" 13th International CODATA Conference, Beijing, China.

May, 1992 – "Decadal to millennial-scale climatic variability" 1992 Spring Meeting of the American Geophysical Union, Montreal (co-chaired with D. Murray).

February, 1992 – "High-resolution studies of past climate" 1992 American Society of Limnology and Oceanography Aquatic Sciences Meeting, Sante Fe, New Mexico (co-chaired with W. Curry).

August 1989 – "The past as a key to understanding future global change," 74th Annual Meeting of the Ecological Society of America, Toronto, Canada (co-convened with G. King).

FIELD EXPERIENCE

2007- Co-leader, Lake coring expedition to Tibet
2004 – Co-leader, Lake coring in the Galapagos
2000 – Co –leader, Lake coring expedition to Ghana
1999 – Co –leader, Lake coring expedition to Ghana
1999 – Leader, Lake and tree coring expedition to Northern Labrador
1998 – Co-leader, Lake coring expedition to Southern Greenland
1997 – Co-leader, Lake coring expedition to Southern Greenland
1997 – Climbed Cerra Aconcagua, 6962m (with D. Anderson)
1996 – Co-leader, Lake coring Baffin Island, Canada and West Greenland.
1996 – Co-leader, Lake coring expedition to Ghana.
1995 – Co-leader, Lake coring expedition to Tibet.
1995 – Co-leader, Lake coring expedition to Nepal.
1994 – Co-leader, Lake coring expedition to Tibet.
1993 – Leader, Lake coring expedition to Nepal.
1993 – Leader, Arctic lake coring expedition, Baffin Island, Canada.

1991 – Leader, Arctic lake coring expedition, Baffin Island, Canada.
1990 – Co-chief Scientist, R/V Washington, Cruise PLUME 7, Cariaco Basin, Venezuela.
1989 – Leader, Arctic lake coring expedition, Baffin Island, Canada.
1989 – Leader, Arctic lake and tree coring expedition, northern Labrador, Canada.
1986 – Scientist, R/V Conrad, Cruise RC27-04, Arabian Sea.
Four winters – Leader, lake coring trips to Upper Midwest US and Canada.

SELECTED PRESS INTERACTION

October, 2008 – Featured and quoted in stories in the *Arizona Daily Star* (front page) and *Tucson Citizen* regarding the new Institute for Environment and Society at the University of Arizona
May 1, 2008 – Quoted in story on decadal climate prediction and the next 10 years of climate change, *Christian Science Monitor*
April, 2008 – Featured in three-day Earth Day series on drought and climate change in the Southwest, *Arizona Daily Star*, Tucson, Arizona.
April, 2008 – Featured on Earth Day, *KOLD TV NEWS 13*, Tucson, Arizona.
March 28, 2008 – Part of an hour-long NPR program *On Point*, focused on the Medieval Warm Period and implications for the future, particularly in the U.S. West.
March 24-28, 2008 – Featured in week-long TV series "Winds of Change" on climate change, KPNX-TV 12 News, Phoenix, AZ
March, 2008 – *Nature Geoscience* paper stories (Neff et al., 2008) reported on by NPR (story on *All Things Considered*) and *New York Times*.
February 1, 2008 – Quoted in a front-page story in the *Washington Post* on climate change and the west being attributed to human causes.
December 29, 2007 – Featured in story about California climate change in an AP story
December 28, 2007 – Featured in climate change and La Niña story in the *Arizona Republic*
November 18, 2007 – Featured in front-page story on climate change in the *San Francisco Chronicle*
November, 2007 – Featured in *History Channel* documentary "'A Global Warning'.
October 22 , 2007 – Featured along with Vice President Gore in NPR program "U.N. Panel Shares Nobel with Gore". Also, featured in multiple newspaper stories around Arizona for sharing Nobel Peace Prize for role as a Coordinating Lead Author in the IPCC Fourth Assessment.
September, 2007 – Featured in widely published *Associated Press* stories on rising sea level.
September, 2007 – Featured in story on university campus sustainability in the *Arizona Daily Star*.
September, 2007 – Featured in story on Arizona climate change and the Western Climate Initiative in the *Havasu News-Herald* (Arizona)
August, 2007 – as of this month, we've had over 100 requests from journalists, media, educators and other outreach entities for future sea level data, images and information. This does not count general use of our lab web resource.
August 24-29, 2007 – Interviewed for KUAT-FM Arizona Spotlight on subject of water sustainability; also was the guess for a 1-hour live talk-radio segment on KVOI-AM, and a shorter interview on KJLL-AM, both focused on the same topic.

July, 15, 2007 – Graduate student Rachael Novak featured in NPR All Things Considered radio show "CLIMATE CONNECTIONS: Drought Threatens Navajo's Crops, Culture".

July, 2007 – Featured in a half-hour documentary by Blur to Focus Productions and The NM State Engineer, entitled: *"Climate Change: What does it mean for New Mexico?"*

July, 2007 – Featured in two stories in the *Wilmington Star* (NC) on future climate and sea level change.

July 9, 2007 – Featured in NPR *Morning Edition* show "CLIMATE CONNECTIONS: A Family Vacations Amidst Changing Landscape " as well as in a an NPR *All Things Considered* show "CLIMATE CONNECTIONS: Ancient Culture Prompts Worry for Arid Southwest."

June, 2007 – Filmed at Mesa Verde for History Channel documentary on climate change.

May, 2007 – Featured in article in *Nature* on start-up company Climate Appraisal Services.

March, 2007 – Featured in story in *USA Today* (and follow-on stories elsewhere) on start-up company Climate Appraisal Services.

February, 2007 – Widely featured in national and international press for role in UN Intergovernmental Panel on Climate Change

November, 2006 – Featured in stories in the Arizona Republic and Arizona Daily Star regarding Supreme Court global warming case.

November, 2006 – Featured in Associated Press story on climate change, Arctic wildfire and greenhouse gas feedback.

October 30, 2006 – Featured in story in the *Albuquerque Journal* on future drought and reduced river flow in the Southwest.

October, 2006 – Featured in stories in the *Denver Post, Farmington Daily Times* and *Grand Junction Sentinel* on climate change and the impacts of this change in the U.S. West and San Mountains of Colorado. Also was focus of 30minute radio interview on the same topic (KDUR, Durango).

August 24, 2006 – Featured in NPR on *All Things Considered* interview about the freshening of the Arctic and potential impacts on the North Atlantic.

August 11 & 15, 2006 – Featured in stories in the *Wall Street Journal* and *USA Today* about accelerating mass loss of the Greenland Ice Sheet

May, 2006 – Featured in major climate change series in *USA Today*

May, 2006 – Taped two 30 minute shows (one on global warming, and one on drought) for *Earthtalk Today* with Alexandra Paul and Peter Kreitler (in Los Angeles, CA).

March and April, 2006 – Expensive global media coverage of two *Science* papers (with cover). Included front page coverage in papers in the US and Canada, NPR interview, and talk radio. Also reported on in *Time Magazine*, *Scientific American.com*

January 30, 2006 – Featured in *Geotimes* online story on record 2005 global temperatures

December, 2005 – Feature guest on Earth Changes TV radio show (ca. 45 minutes of talk radio)

August, 2005 – extensive press coverage of *EOS* paper, at least 130 print media articles in first week. Press interest still alive at end off year. Included request from U.S. Congress for article.

May 26, 2005 – Guest on KUAT TV *Arizona Illustrated* TV show

February 16, 2005 – Featured in front-page article on climate change and forest health in the *Arizona Daily Star*.
February 14, 2005 – Featured in front-page article on the climate change debate in the *Wall Street Journal.*
Febuary 6, 2005 – Featured in article on drought and climate change in the *Washington Post*.
Feburary 5, 2005 – Guest on talk radio show "Weather Talk with Paul Huttner"
January24, 2005 – Featured in cover story on past climate change in the West. *High Country News*.
January 30, 2005 – Featured in article on global warming in the *Arizona Daily Star*.
January 10, 2005 – Featured in article on Arctic climate change – United Press International (including the *Washington Times*)
January 5, 2005 – Guest on KUAT TV *Arizona Illustrated* TV show.
December, 2004 – Co-author full page Op-Ed "Perspective" on climate change in December 13, 2004 *Tucson Citizen*.
July, 2004 – Featured in Weather Channel special on climate change: "Forecast Earth: A Planet in Change"
June, 2004 – Participant in CLIVAR (World Climate Research Programme Climate Variability and Predictability Programme) Open Science Conference Press Conference, Baltimore MD
May 25, 2004 – Participant in press conference and pre-screening of 20th Century Fox Feature Movie: "Day after Tomorrow," Tucson, AZ.
April 22, 2004 (Earth Day Week) – Sea level research and web site (UA Dept of Geoscience Environmental Studies Lab) featured on National Geographic Web site main page.
April, 14, 2004 – Live interview on KTAR Radio, Phoenix morning show – drought issues
April, 2004 – Interviewed for NPR Feature on abrupt climate change
April, 2004 – Interviewed for article(s) on arctic environmental change for *New Yorker* magazine.
April, 2004 – Interviewed for Evening News, Channel 4 TV, Tucson
October 29, 2003 – Featured in articles on arctic climate that appeared in the *Seattle Post-Intelligencer* and elsewhere.
June 15, 2003 – Featured in story on water crisis in the *Houston Chronicle*
June 22, 2003 – Featured in story "Climate Boom & Bust: High Population Suffers More in Dry Times" in the *Albuquerque Journal.*
May 21, 2004 – Interviewed about drought on KUAT-TV show *Arizona Illustrated*.
May 9, 2003 – Featured in story on drought in the *Arizona Daily Star*
April, 2003 – Multi-day film shoot in Tucson region for documentary "The Venus Theory – a documentary film on climate change" (52 minutes) Talent House, Helsinki 2004.
December 16, 2002 – Guest for 20 minutes on KPRA (Berkley CA) radio morning show
December 8 2002 – Featured in climate change stories in Los Angeles Times and Seattle Times
May 9, 2001 – Authored invited 2-page "Insight and Opinion" article titled "Global warming is all too real," Albuquerque Tribune

April 19, 2001 – Featured in story on NSF-sponsored Holocene climate change workshop, Richmond Times-Dispatch

April 12, 2001 – Featured in story on global warming and mathematics in Tucson Citizen

March 15 2001 – Guest on one-hour AM990 (KTKT-Tucson) Reed Schmidlin talk radio show

March 8. 2001 – Featured in lead story on Tucson Channel 13 (CBS) report on global warming and how it could impact the US and US Southwest

January, 19 2001 – Featured in climate change story – Honolulu Star-Bulletin "Climate prediction could ease global warming's impact, geologist says"

Spring, 2000 – Featured in Los Angles Times front page story on climate change, 2000

April, 2000 – Featured in NOVA/Frontline 2-hour documentary "What's up with the weather?"

February, 2000 – Guest Opinion titled "Global Warming Is Not Pseudo-Science" published in Sunday Feb. 13 issue of Arizona Daily Star (co-authored with Julie Cole).

December, 1999 – Science results featured on www by University Science (unisci.com/) and Yahoo! News

December, 1999 – Interview with University of Arizona News Services aired on state-wide radio program

December, 1999 – Interviewed for article on paleoclimatology in the Christian Science Monitor – 1 page article appeared Jan 18, 2000

August, 1999 – Interviewed by South Africa Broadcast Company television story on climate change and first World Data Center in Africa.

July, 1999 – Interviewed on National Public Radio Story on Siberian Environmental Change

July, 1999 – Interviewed by US News & World Report for background on climate story

June, 1999 – Interviewed for South African radio show – climate change

May, 1999 – Interviewed for NOVA/FRONTLINE documentary on global warming

May, 1999 – Interviewed for global warming article in "Rolling Stone"

April, 1999 – Interviewed for global warming story in "Popular Science"

March, 1999 – BBC film team accompanied Overpeck research team on Arctic field expedition for three days of filming/interviewing for documentary on Atlantic climate change. Results featured in 60 minute documentary "The Bill Chill"

December, 1998 – Lead scientist in NOAA Press Conference on drought variability (at National Press Club, Washington). Reported live on national network television and radio programs, plus reports appeared around nation in print media

July, 1998 – Interviewed on National Public Radio's "All things considered" – helping to put the summer 1998 heat wave in perspective

February, 1998 – Arctic Warming Press Kit requested by, and provided to Executive Office of the President, Council on Environmental Quality

January, 1998 – Interview on Arctic environmental change distributed by Arctic Science Journeys radio news service

December, 1997 – Interviewed for story in Earth Magazine that was published early in next year

November, 1997 – Lead scientist in joint NOAA-NSF Press Conference on Arctic Climate Change, Washington, DC. Reported on in newspapers across US and Canada (often on front page), as well as on TV (CNN) and National Public Radio. Also covered in Europe.

November, 1997 – Interviewed for background on 4-day series on Global Warming that appeared in the Washington Post during the week of Nov. 10.

August, 1997 –Quoted in Washington Post "Horizon" feature on Little Ice Age. Included photos taken during 1997 Greenland field season

March, 1997 – Research mentioned in "Computer Life"

January, 1997 – Featured in "Science News"

December, 1996 – Featured in "Washington Times"

December, 1996 – Featured as lead article in Discovery Section of "Boulder Daily Camera"

November, 1996 – Focus of 8-page interview in "Environmental Review"

September, 1996 – Participated in "State of the Climate" briefing at the National Press Club, Washington. Broadcast on CSPAN and reported by over 150 newspapers nation-wide.

June, 1996 – Appeared on "ABC Nightly News"

June, 1996 – Featured in "Sea Technology"

May, 1996 – Featured in "New York Times"

March, 1996 – Featured in cover story in "Science News"

Pre-1996 – Didn't keep track of press interaction, but was featured several times in print media, including "Wall Street Journal" and "Washington Post." Also appeared on National Public Radio.

SERVICE ON EDITORIAL BOARDS

Spring, 2007 – Founding Editor (with M. Miller and B. Morehouse) of the new "*Environmental Science, Law, and Policy*" book series, University of Arizona Press and partners (to present).

May, 2006 – Appointed to Board of Reviewing Editors, *Science* (to present)

January, 1993 – Appointed to the Editorial Advisory Board of *Quaternary Science Reviews* (to present)

January, 1993 – Appointed to the Editorial Board of *Geology* (2-year term).

OTHER PROFESSIONAL ACTIVITIES

May, 2008 – Invited to present testimony at hearing on "Water Supply Challenges for the 21st Century", Committee on Science and Technology, U.S. House of Representatives, Washington, DC.

April, 2008 – Invited Speaker, Texas A&M University, College Station, TX

April, 2008 – Invited Speaker, University of Washington public evening lecture

April, 2008 – Invited Speaker, Rotary Club luncheon lecture, Seattle, WA

April, 2008 – Invited Speaker, Pacific Science Center Evening Lecture, Seattle, WA

March, 2008 – Invited speaker, "Solar Rock" event, Tucson, AZ

March, 2008 – Invited dinner speaker, Spring meeting of the Montrose Memorial Hospital staff and friends.

March, 2008 – Invited Speaker, Yale Club, Tucson, AZ
March, 2008 – Invited Speaker, Arizona Science Center, Phoenix, AZ
March, 2008 – Invited Speaker, Honors College Luncheon
March, 2008 – Invited Speaker, BIO5 and other units, University of Arizona, Tucson, AZ
February, 2008 – Invited Speaker, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO.
January, 2008 – Invited Speaker, Frankel Foundation Board Retreat, Phoenix, AZ.
November, 2007 – Invited Speaker and Panel Member, Climate Change and the Role of Higher Education in Arizona: *Preparing our Students for a Changing World,* Phoenix, AZ.
October, 2007 – Invited Speaker, Water Policies and Planning in the West: Ensuring a Sustainable Future, Western Governors' Association and the Western States Water Council, Salt Lake City, UT.
October, 2007 – Invited Speaker, Department of Soil, Water and Environmental Sciences, University of Arizona, Tucson.October, 2007 – Invited Evening Speaker, Arizona Association for Environmental Educators conference, Tucson, Arizona.
October, 2007 – Invited speaker, series of three lectures sponsored by the State Engineer of New Mexico, Albuquerque and Santa Fe, New Mexico.
October, 2007 – Invited Speaker – New Mexico Climate Change Ecology and Adaptation Workshop, Albuquerque, New Mexico.
October, 2007 – Invited Evening Speaker on Climate Change, Public Forum Co-sponsored by The Nature Conservancy and the University of Chicago, Chicago, Illinois.
October, 2007 – Invited Workshop Participant, "Future Climate Change Research and Observations: GCOS, WCRP and IGBP Learning from the IPCC Fourth Assessment Report," Sydney, Australia
September, 2007 – Taaffe Lecturer, Ohio State University, Columbus, Ohio.
September, 2007 – Invited Speaker, Border Institute-IX: Security, Development and the Environment at the U.S.-Mexican Border.
August, 2007 – Invited Speaker, 2007 Regional Water Symposium: "Sustainable Water, Unlimited Growth, and Quality of Life: Can We Have It All?", Tucson, AZ
July, 2007 – Invited Seminar Speaker, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
May, 2007 – Invited Speaker, "Dividing the Waters: Science for Judges Workshop IV," Boulder, Colorado
March, 2007 – During a visit to the U.S. House of Representatives, gave an hour-long briefing "Global Warming and the Impacts in the American West" hosted by the House Committee on Science, and also met w/ staffers of two western Congressmen (Rep. Renzi and Rep. Matheson).
March, 2007 – Invited Speaker – National Science Foundation Earth System History Meeting, Washington, DC.
March, 2007 – Invited Speaker, OUT LOUD Program, Telluride, Colorado.
March, 2007 – Invited Speaker, Arizona Board of Regents Meeting.
March, 2007 – Invited Speaker, UK Royal Society Meeting on Climate Change.
February, 2007 – Briefed Congresswoman Giffords on climate change, the IPCC, and what it means for Arizona.

February, 2007 – Met with Congressman Bart Gordon, and participated a House Committee on Science and Technology Briefing on “Sea Level Rise – The State of the Science;” in the afternoon repeated the briefing for staff members of the U.S. Senate Committee on Environment and Public Works
February, 2007 – Invited Speaker, UN/WMO IPCC Working Group I Plenary.
December, 2006 – Invited Speaker, American Geophysical Union Fall Meeting
December, 2006 – Invited Panelist, Interfaith Discussion of Climate Change, Tucson, AZ
November, 2006 – Invited speaker, Earth System Science Partnership, Beijing, China.
October, 2006 – Invited speaker, Governor of New Mexico’s Fourth Annual Drought Summit
October, 2006 – Invited speaker, San Diego Natural History Museum
October, 2006 – Invited speaker, University of Arizona College of Science Public lecture series “Global Climate Change,” Tucson
October, 2006 – Invited speaker, Climate Variability & Change in the San Juan Mountains: A Scientist-Stakeholder Dialogue, Durango, CO
October, 2006 – Invited evening speaker, Fort Lewis College, Durango, CO
September, 2006 – Invited speaker, Arizona Academy Village, Tucson
August, 2006 – Invited speaker – 36th American Quaternary Association Biennial Meeting, Bozeman, MT.
July, 2006 – Invited participant, UN/WMO Intergovernmental Panel on Climate Change Fourth Lead Authors Meeting, Bergen, Norway.
June, 2006 – Invited participant and speaker, IGBP PAGES/ WCRP CLIVAR Workshop on ‘Past Millennia Climate Variability’, Wengen, Switzerland.
June, 2006 – Invited speaker (1 hour plenary) – 11th Annual Community Climate System Model Workshop, Breckenridge, CO.
May, 2006 – Invited speaker – MountainFilm, Telluride, CO
May, 2006 – Scientific co-author/member of *Amici Curiae* brief to the U.S. Supreme Court – focused on climate change
April, 2006 – Dinner speaker, Climate and Energy Funders Group, Phoenix, AZ.
February, 2006 – Invited speaker, Alaska Forum on the Environment, Anchorage, AK.
January, 2006 – Invited speaker (1 hour plenary), 5th Annual conference of the Quivira Coalition – 'Bridging the Urban-Rural Divide', Albuquerque, NM.
January 2006– Elected Vice President of the Board for the Mountain Studies Institute, Silverton, Colorado
December, 2005 – Invited seminar speaker, Fort Lewis College
December, 2005 – Invited participant and speaker, UN/WMO Intergovernmental Panel on Climate Change Third Lead Authors Meeting, Christchurch New Zealand
November, 2005 – Invited speaker, Climate, Oceans and Policies – Challenges for the 21st Century Conference, Royal Norwegian Embassy and The Carnegie Institution, Washington, DC.
October, 2005 – Invited speaker and participant, Climate Change and Conservation Workshop, The National Center for Ecological Analysis and Synthesis (NCEAS), Santa Barbara, CA.
September, 2005 – Invited speaker and participant, National Research Council Board on Atmospheric Sciences and Climate Workshop on Multiple Environmental Stresses, Irvine, CA.

September, 2005 – Invited dinner speaker and participant, Conference on Urban Water Supplies and Climate Change in the West, Las Vegas, NV.
August 2005 – Elected Member of the Board for the Mountain Studies Institute, Silverton, Colorado
July, 2005 – Gave public lecture on climate change ("Climate Change: What's Ahead for the West") sponsored by the New Mexico State Environment Department, Santa Fe, NM
July, 2005 – Invited lunch speaker, State of New Mexico Climate Change Advisory Group Meeting #1, Santa Fe, NM
July, 2005 – Discussion speaker, Pinhead Institute Town Talk, Telluride, CO.
June, 2005 – Participant/speaker, San Juan Mountains Research Retreat, Mountain Studies Institute, Silverton, CO
May, 2005 – Invited speaker and participant, NASA-NOAA Workshop on "Observational and modeling requirements for predicting drought on seasonal to decadal time scales," University of Maryland
May, 2005 – Invited participant, UN/WMO Intergovernmental Panel on Climate Change Second Lead Authors Meeting, Beijing, China.
April, 2005 – Invited Speaker, University of Arizona Dean of Students Faculty Lecture Series; talk title: "Drought: Lessons from the Future."
April, 2005 – Dinner Speaker at informal meeting of water managers for Albuquerque and the state of New Mexico
March, 2005 – Invited speaker, Arizona Geological Society meeting, Tucson, AZ.
February, 2005 – Invited speaker and participant, Workshop on "Climate Change & Ecosystem Impacts in Southwest Forests and Woodlands," Sedona, AZ.
February, 2005 – Guest lecturer, Environmental Law Seminar, University of Arizona.
April, 2004 – Invited Speaker – "Perspectives on Abrupt Climate and Environmental Change, "Briefing for the NSF Geosciences Directorate.
February, 2004 – Testified in support of Arizona State Senate Bill 1227 (State Climate Change Study Committee); Senate Natural Resources and Transportation Committee
February, 2004 – Panel Member, Plenary Session on ""Managing Fish and Wildlife in the face of Climatic Variability," 37th Annual Joint meeting of the Arizona and New Mexico Chapters of The Wildlife Society and the Arizona/New Mexico Chapters of the American Fisheries Society, Safford AZ.
November, 2003 – Invited Speaker New Mexico Council of Churches conference "Is Global Warming Too Hot to Handle?," Albuquerque MN
October, 2003 – Invited Plenary Speaker, Panel Member and Press Conference Participant, Study of Environmental Arctic Change (SEARCH) Open Science Meeting, Seattle, Washington
September, 2003 – Invited Participant and Speaker, UN Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Second Scoping Meeting, Potsdam, Germany
May, 2003 – Invited speaker, Inagural Meeting of the Arizona Governor's Drought Task Force
April, 2003 – Invited Participant and Speaker, UN Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment First Scoping Meeting, Potsdam, Germany
April, 2003 – Invited Keynote Speaker, University of New Mexico Center for the Southwest Conference "Heating up: Coping with Climate Change in the Southwest"
April, 2003 – Invited Plenary Speaker, International Limnogeology Congress, Tucson, AZ

April, 2002 – Keynote Speaker, NSF Workshop on "Antarctic Peninsula Climate Variability: A Historical and Paleoenvironmental Perspective," Clinton, NY.
April, 2002 – Invited Speaker, University of New Mexico
March, 2002 – Invited seminar speaker, University of New Mexico
March, 2002 – Invited SEPM 2002 Annual Business Meeting Luncheon Distinguished Speaker, Houston, TX
January 2002 – Invited lunch speaker. "Regional climate services: The RISA* Experience" NOAA Climate Services Workshop, Columbia, Maryland.
December 2001 – Invited plenary speaker "Building Native Nations: Environmental, Natural Resources, and Governance" conference, Tucson, AZ
August 2001 – Invited plenary speaker, *IGBP PAGES – PEPIII: Past Climate Variability Through Europe and Africa*, August 2001, Aix-en-Provence, France.
November, 2001 – Laboratory for Tree-ring Research, Colloquium, November 2001
April 2001 – Invited Speaker, NOAA Climate Diagnostics Lab, Boulder, CO
April 2001 – Attended lunch briefing with Arizona Congressmen Kolbe and Flake to discuss University of Arizona interaction with Columbia University and the Biosphere 2 Center, Washington, DC
April 2001 – Invited Speaker, NSF Workshop "Reconstructing Late Holocene Climate," Charlottsville, VA
April 2001 – Invited speaker, University of Arizona Math Awareness Week
March 2001 – Invited seminar speaker, Scripps Institute of Oceanography
March 2001 – Invited seminar speaker, University of Minnesota
March 2001 – Invited speaker at NSF PARCS workshop, Amherst Massachusetts
March 2001 – Invited speaker and Earth System Science advisor, University of Wyoming
Febuary 2001 – "Climate, fire and the need for a national climate service." NOAA-USDA Fire and Climate 2001 Workshop, Tucson, AZ.
January, 2001 – Invited speaker at *NASA/IPRC Colloquium on Decadal Climate Variability,* Honolulu HI
September 2000 – Invited speaker, Annual Meeting of The Nature Conservancy, Tucson, AZ
July 2000 – Invited participant and speaker, Yale/NBER/IIASA program on International Environmental Economics Workshop on "Potential Catastrophic Impacts of Climate Change", Snowmass, CO
August 2000 – Gave invited lecture to UA Ecology and Evolutionary Biology Dept. as part of their seminar series
May 2000 – Gave talk "A global perspective on climate change" to US Department of State "Senior Seminar," Tucson, AZ
March 2000 – Gave invited Holmes lecture, Syracuse University.
December, 1999 – Gave invited lecture to UA Geography Dept. as part of their seminar series
October, 1999 – Invited Speaker/Panelist "Hot Topics" Session entitled "Climates Change, Get With It!" at 1999 Annual Meeting of the Geological Society of America, Denver, CO.
November, 1999 – Invited Panelist and Speaker in "Special Symposium on Global Warming" at the 1999 American Nuclear society Winter Meeting (Long Beach, CA). Talk titled "Measuring climate change: climates and climate changes of the past."
August, 1999 – Invited participant and speaker, Aspen Global Change Institute on "Ecological and Agricultural Consequences of Past, Present and Future Climatic Extremes," Aspen, CO.

August, 1999 – Gave invited seminar on recent climate change at University of Durban, South Africa

August, 1999 – Gave three invited short-course/demonstration of The World Data Center-A for Paleoclimatology sytem, International Quaternary Association Meeting, Durban, South Africa. Included television interviews with South African Broadcasting Service.

May, 1999 – Invited speaker/participant NASA Team Meeting (Arlie, VA) Presented overview of "Assessing Future Stability of US High Plains Landcover: Integration of Process Modeling with Landsat, In Situ Modern and Paleoclimate Data"

Spring, 1999 – Invited lecturer, Trinity College, Dublin

June, 1998 – Invited lecturer, European Commission Advanced Study Course on Holocene Climate Reconstruction, Environmental Change Research Centre, University College, London

June, 1998 – Invited Participant, US-European Commission Conference "New Vistas in Transatlantic Science and Technology Cooperation," Washington, DC.

April, 1998 – Invited Speaker, IGBP PAGES Open Science Meeting, London, England.

February, 1998 – Invited Participant, Sixth Japan-U.S. Workshop on Global Change Research, Honolulu, Hawaii

February, 1998 – Nominated for Lead Author, 2000 Intergovernmental Panel on Climate Change (IPCC)

February, 1998 – Invited Plenary Speaker and Participant, IGBP PAGES 2nd International Workshop on Global Paleoenvironmental Data, Boulder, Colorado

January, 1989 – Invited Speaker, National Science Foundation Earth System History Interagency Briefing, Washington, DC

January, 1989 – Invited Speaker, US Global Change Research Program Congressional Seminar Series, Washington, DC

January, 1998 to 2000 – Invited Content Advisor, Smithsonian Institution's planned new "Forces of Change" National Museum of Natural History exhibit and "From Grass to Grain" traveling exhibit.

January, 1997 to 1998 – Senior US Scientist, Gore-Chernomyrdin US-Russia Environmental Working Group.

December, 1997 – Invited Seminar Speaker – University of Alaska-Fairbanks

November, 1997 – Preprint of Science paper "Arctic Environmental Change of the Last Four Centuries" sent by Dr. James Baker (Under Secretary for Oceans and Atmosphere) to Vice President Gore, along with explanatory memo).

November, 1997 – Invited seminar speaker – McGill University, Montreal

November, 1997 – Invited seminar speaker – University of Montreal, Montreal

November, 1997 – Invited seminar speaker – UC Santa Cruz, Santa Cruz, CA

November, 1997 – Invited participant, IGBP PAGES (Past Global Changes) Leader Meeting, Hilterfingen, Switzerland

September, 1997 – Invited participant and speaker, WCRP CLIVAR Science meeting, Abisko, Sweden.

June, 1997 – Invited participant and speaker, National Center for Atmospheric Research "Climate System Model" workshop. Breckenridge, CO

May, 1997 – Invited Speaker, NSF ARCSS OAII Principal Investigators Meeting, Virginia Beach.

Winter, 1997 – Member – NSF Arctic System Science (ARCSS) Science Integration Plan Writing Team.

April, 1996 – Plenary Speaker and Working Group Co-Chair, Arctic System Science (ARCSS) All-Hands Workshop, Utah

Spring, 1996 – Member, Ocean Drilling Program Leg 165 Science Party

February, 1996 – invited speaker at first ever joint meeting of the NRC (National Research Council) "GOALS" and "DEC-CEN" climate research panels, Irvine, CA.

October, 1995 – Speaker and Working Group Leader, All World Data Center Meeting, Netherlands

April, 1995 – Invited participant, speaker and discussion leader "International Himalayan/Tibetan Plateau Paleoclimate Workshop" Kathmandu, Nepal

1994-1997 – Collaborator on funded National Science Foundation Grant ATM-94: "Long-term dynamics of the SW Indian monsoon: New high-resolution paleoclimatic data from Tibet" (funding thru Dr. K-B Liu).

April, 1994 – Invited participant, IGBP PAGES workshop and planning meeting "PEPII – Pole-Equator-Pole Australasia transect," Beijing, China.

1991 to present – Invited participant, and representative of the NOAA Paleoclimatology Program, at 2-3 meetings per year of the NOAA Panel on Climate and Global Change

October, 1994 – Invited participant, NATO Workshop "Climatic variability and forcing mechanisms of the last 2000 years." Tuscany, Italy

December, 1993 – Guest Editor, Special Issue of *Quaternary Science Reviews*, "Decadal to Millennial-scale Variability in the Climate System"

December, 1993 – Invited participant and co-author of IGBP PAGES workshop report "PEPIII – Pole-Equator-Pole Europe-Africa Transect," Bern Switzerland.

October, 1993 – Invited participant, NATO Workshop "Strategies for the use of paleoclimatic data sets in climate model intercomparison and evaluation," Aussois, France.

April, 1993 – Invited participant, speaker, and group leader at IGBP Workshop "High-resolution records of past climate from monsoon Asia," Taipei, Taiwan.

March, 1993 – Invited participant and speaker, NSF-Russian Workshop "Paleoclimates of Arctic Lakes and Estuaries," Vladivostok, Russia. Co-authored protocols for international collaboration in the study of Arctic paleoclimates using lake sediments.

December, 1992 – IGBP PAGES representative to meeting of the IGBP-DIS Standing Committee and to discussions of joint PAGES-IGBP GCTE (Global Change and Terrestrial Ecosystems) research, Canberra, Australia.

December, 1992 – Invited lecturer at the Research School of Biological Sciences at the Australian National University.

November, 1992 – Invited participant and speaker at the Advisory Committee on Nuclear Waste Working Group Meeting: "On the impact of long-range climate change in the area of the southern Basin and Range," Washington, DC.

September, 1992 – Invited participant in NOAA-sponsored workshop "Human Dimensions of Global Change," Washington, DC.

September, 1992 to May, 1994 – Gave hour-long invited seminars at the University of Colorado (Geological Sciences), the NOAA Geophysical Fluid Dynamics Lab (Princeton), the Colorado School of Mines (Geology), The University of Wyoming (Geology), the University of Massachusetts (Geography and Geology) and the University of Washington (Quaternary Research Center – two lectures).

December, 1991 – Invited participant, Dahlem Workshop on "Global Changes in the Perspective of the Past," Berlin, Germany.

November, 1991 – Invited participant and discussion leader, NOAA/NASA/NSF Workshop: "Late Quaternary Paleoclimate Model Boundary Conditions," New York.

September, 1991 – Invited Guest and Lecturer, Center for Climate System Research, University of Tokyo.

June, 1991 – Invited member, US delegation to meeting of Working Group VIII (Influences of Environmental Changes on Climate) of the US/USSR Agreement on Protection of the Environment, Bellagio, Italy.

March, 1991 – Invited participant and Theme Leader, First meeting of the Scientific Steering Committee of the IGBP Past Global Changes (PAGES) Core Project, Mainz, Germany.

August, 1990 – Invited participant and paleoclimatology representative – U.S. (NSF/NASA) Bilateral Agreement with the People's Republic of China (State Meteorology Agency) Climate Workshop, Shanghai, PRC.

January, 1990 – Invited participant, GICME II Workshop – "Geological Indicators of Climate from Marine Environments," St. Petersburg, FL.

November, 1989 – Invited participant, EPA/OPPE "Workshop on Tropical Forests," Washington DC.

August – September 1989 – Visiting Scientist, Laboratoire de Palynologie C.N.R.S., Montpellier, France.

July – August 1989 – Invited participant, Second UCAR/OIES Global Change Institute, "Explaining records of past global change," Snowmass, Colorado.

July, 1989 – Invited contributor and speaker, "Global Climate Change and its Effects on California," Davis, California.

1989 – 1990 – Original member of the NOAA Paleoclimate Advisory Panel.

November-December 1988 – Visiting Scientist, Laboratoire de Palynologie C.N.R.S., Montpellier, France.

September 1988 – Invited participant, Committee on the Earth Sciences review of methodologies for EPA's reports to Congress, Washington DC.

August 1988 – Elected Vice-Chairperson/ Chair-Elect of the Paleoecology Section of the Ecological Society of America.

April 1988 – Invited participant, NSF workshop on Arctic Lake Coring, Boulder, Colorado.

April 1988 – Review workshop for EPA's Report to Congress on the Effects of a Global Warming, Bethesda, Maryland.

February 1988 – Invited participant and speaker, NSF/NOAA Paleoecology workshop: "A meeting on the present status and future of studies of the paleosedimentary records of nearshore marine and freshwater lakes related to climate and global change," Boston, Massachusetts.

October 1987 – Invited participant, U.S. EPA Meeting of the Principal Investigators for "The Report to Congress on the Effects of a Global Warming," Alexandria, Virginia.

September 1987 – Invited participant, U.S. EPA Workshop: "Global Climate Change Research Plan," Raleigh, North Carolina.

May 1987 – Invited participant and speaker, NSF (Division of Polar Programs) workshop: "The Contribution of Lake Sediments to Arctic Paleoenvironmental Reconstructions," Boulder, Colorado.

April 1987 – Invited participant, U.S. EPA Workshop: "Ecological Effects of Global Climate Change," Boulder, Colorado.

April 1987 – Invited participant and speaker: "United Nations Meeting of Experts on Space Technology and its Applications within the Framework of Educational Systems," Lagos, Nigeria.

1986 to present – Reviewer for U.S. EPA, NSF, DOE, NOAA, NGS, ODP, USGS, NPS, several foreign funding agencies, and numerous scientific journals.

1986 – Consultant to the U.S. EPA.

1984 to 1986 – Member COHMAP (Cooperative Holocene Mapping Project).

PROFESSIONAL MEMBERSHIPS

American Geophysical Union
American Meteorological Society
American Quaternary Association
Ecological Society of America
Geological Society of America
Sigma Xi

PUBLICATIONS (Peer-reviewed journals and book chapters)

101. Weiss, J.L., C. L. Castro and J. T. Overpeck. (2008). The Changing Character of Climate, Drought, and the Seasons in the Southwestern U.S.A. ***Journal of Climate*** (submitted).
100. Conroy, J. L., J.T. Overpeck, M. Steinitz-Kannan, and J.E. Cole. (2009). The tropical Pacific–western North American drought teleconnection over the last 1200 years. ***Geophysical Research Letters*** (in final co-author review).
99. Jones, P.D., K.R. Briffa, T.J. Osborn, J.M. Lough, T.D. van Ommen, B.M. Vinther, J. Luterbacher, E. R. Wahl , F.W. Zwiers, M.E. Mann, G.A. Schmidt, C. M. Ammann, B.M. Buckley, K. M. Cobb, J. Esper, H. Goosse, N. Graham, E. Jansen, T. Kiefer, C. Kull, M. Küttel, E. Mosley-Thompson, J.T. Overpeck, N. Riedwyl, M. Schulz, A. W. Tudhope, R. Villalba, H. Wanner, E. Wolff and E. Xoplaki (2009). High-resolution paleoclimatology of the last millennium: a review of current status and future prospects. ***The Holocene*** (in press).
98. Overpeck, J.T. and J.E. Cole (2008). The rhythm of the rains. ***Nature*** 451, 1061-1063.
97. Conroy, J. L., J.T. Overpeck, M. Steinitz-Kannan, and J.E. Cole. (2009). Unprecedented recent warming in the eastern tropical Pacific. ***Nature Geoscience*** (in press).

96. Conroy, J. L., J.T. Overpeck, J.E. Cole, T.M. Shanahan, and M. Steinitz-Kannan. (2007). Holocene changes in eastern tropical Pacific climate inferred from a Galápagos lake sediment record. ***Quaternary Science Reviews*** (in press).
95. Neff, J.C., A.P. Ballantyne, G.L. Farmer, N.M. Mahowald, J. Conroy, C.C. Landry, J. T. Overpeck, T.H. Painter, C.R. Lawrence and R. Reynolds (2008). Recent increases in eolian dust deposition due to human activity in the western United States. ***Nature Geoscience*** (in press).
94. Shanahan, T., J.T. Overpeck, C.A. Scholz, J. W. Beck, Scholz, J. Peck and J.W. King (2007). Abrupt changes in the water balance of tropical West Africa during the late Quaternary. ***Journal of Geophysical Research*** (in press).
93. Scholz, C.A, T.C. Johnson, A.S. Cohen, J.W. King, J.A. Peck, J.T. Overpeck, M.R. Talbot, E.T. Brown, L. Kalindekafeh, P.Y.O. Amoakoi, R.P. Lyons, T.M. Shanahan, I.S. Castaneda, C.W. Heile, S.L. Forman, L.R. McHarguek, K.R. Beuning, J.Gomez, and J.Pierson (2007). East African megadroughts between 135 and 75 thousand years ago and bearing on early-modern human origins. ***Proc. of the National Academy of Sciences*** 104, 16416-16421.
92. Shanahan, T.M., J.T. Overpeck, J.B. Hubeny, J. King, F.S. Hu, K. Hughen, G. Miller, J. Black, A. Werner (2007. Scanning m-XRF elemental mapping: a new tool for the study of laminated sediment records. ***Geochemistry, Geophysics, Geosystems*** (in press).
91. Shen, C., K-b Liu, C. Morrill, J.T. Overpeck, J. Peng and L. Tang (2008). Meadow-steppe ecotone shift and major centennial-scale droughts during the Mid-Late Holocene in the central Tibetan Plateau. ***Ecology*** 89, 1079-1088.
90. Overpeck, J.T. and J.E. Cole (2007) Lessons from a distant monsoon. ***Nature*** 445, 270-271.
89. Koeberl C., Milkereit B., Overpeck J. T., Scholz C. A., Amoako P. Y. O., Boamah D., Danuor S.K., Karp T., Kueck J., Hecky R. E., King J., and Peck J. A. 2007. An international and multidisciplinary drilling project into a young complex impact structure: The 2004 ICDP Bosumtwi impact crater, Ghana, drilling project – An overview. ***Meteoritics & Planetary Science*** 42, 483-511.
88. Potter, J. and others. **Climate Change**: An Information Statement of the American Meteorological Society, Boston, MA
87. IPCC, 2007: Summary for Policymakers. ***In***: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (Solomon, S. et al., eds). Cambridge University Press. Cambridge. Pages 1-18.
86. Solomon, S. and others. Technical Summary. ***In***: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (Solomon, S. et al., eds). Cambridge University Press. Cambridge. Pages 19-91.
85. Jansen, E., J.T. Overpeck and 47 others. 2007. Chapter 6: Paleoclimate. ***In***: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (Solomon, S. et al., eds). Cambridge University Press. Cambridge. Pages 433-497.
84. Morehouse, B. G. Christopherson, M. Crimmins, B. Orr, J. Overpeck, T. Swetnam, and S. Yool. (2006). Modeling interactions among wildland fire, climate and society in the context of climate variability and change in the Southwest US. ***In***: "Regional Climate Change and Variability," M. Ruth, K. Donaghy and P. Kirshen, eds., Edward Elgar, Cheltenham, UK, 58-78.

83. Overpeck J.T. and J.E. Cole. 2006. Abrupt change in the Earth's climate system. ***Ann. Rev. Environment and Resources*** 31, 1-31.
82. Kerwin, M. W., Overpeck, J. T., and Webb, R. S. 2006. Corresponding patterns of modern lake sediment pollen and vegetation in boreal, subarctic, and Arctic regions of eastern Canada. ***Review of Palaeobotany and Palynology*** (submitted).
81. Shanahan, T., Overpeck, J. T., Wheeler, C. W., Beck, J. W., Pigati, J. S., Talbot, M. R., Scholz, C. A., Peck, J., and King, J. W. 2006. Paleoclimatic variations in West Africa from a record of late Pleistocene and Holocene lake level stands of Lake Bosumtwi, Ghana. ***Palaeogeography Palaeoclimatology Palaeoecology*** (in press).
80. Shanahan, T.M., J.T. Overpeck, E. Sharp, C.A. Scholz, and J. Arko. 2007. Simulating the response of a closed basin lake to recent climate and land-use changes in tropical West Africa (Lake Bosumtwi, Ghana). ***Hydrological Processes*** 21, 1678-1691.
79. CAPE_Last_Interglacial_Project_Members. 2006. Last Interglacial Arctic Warmth Confirms Polar Amplification of Climate Change. ***Quaternary Science Reviews*** 25, 1383-1400.
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Overpeck, J.T. 1996. "The rapidly changing Arctic environment: a paleoenvironmental perspective." Arctic System Science (ARCSS) All-Hands Workshop, Snowbird, UT.

Overpeck, J.T. 1995. "The Need for Improved Global Paleoenvironmental Databases," 14th Symposium de l'Association des Palynologues de Langue Francaise, Paris.

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Overpeck, J.T. 1994. "The paleoclimate record and its role in understanding the greenhouse effect" International Conference on Global Climate Change: Science, Policy, and Mitigation Strategies, Phoenix, AZ

Webb, R.S., P.J. Bartlein, and J.T. Overpeck. 1993. "The paleoclimate record of long-term climate variability." Ecological Society of America Annual Meeting.

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Overpeck, J.T. 1990. "The past as a key indicator for assessing future climate-induced ecologic change." International Symposium on Ecological Indicators, Fort Lauderdale.

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Overpeck J.T. 1989. "Lake sediments, climate modeling, and global climate change." Keynote speaker in workshop on "Large Lakes and Global Climate Change," 24th Congress of the International Association of Theoretical and Applied Limnology, Munich, FRG.

Peterson, L.C., J.T. Overpeck, N.Kipp, J.Imbrie, and D.Rind. 1989. "A high-resolution record of the last deglaciation from the anoxic Cariaco Basin." Third International Conference on Paleoceanography, Cambridge, Great Britain.

Overpeck, J.T. and D. Rind 1989. "Climate and biotic change: past, present, and future." Ecological Society of America Annual Meeting, Toronto.

Overpeck, J.T. 1988. "Modeling the transient response of vegetation to climatic change: a paleoecologic time series perspective." Ecological Society of America Annual Meeting, Davis, California

Overpeck, J.T. 1987. "Paleoclimatic perspectives on the global carbon cycle: past, present, future." Symposium Inaugurating the University of London Quaternary Research Centre and celebrating Agassiz and 150 years of Quaternary Research, Surrey, England.

Overpeck, J.T. and E.R. Cook. 1987. "A Quaternary perspective on how trace-gas-induced climate change might affect natural vegetation: data and methods." XII-th Congress of the International Quaternary Association, Ottawa, Canada.

Overpeck, J.T. 1987. "Pollen, vegetation, climate, and the interval 18,000 to 9000 YR B.P.: numerical techniques in the search for truth." XII-th Congress of the International Quaternary Association, Ottawa, Canada.

Overpeck, J.T. 1985. "Pollen time series and Holocene climate variability of the Midwest United States." NATO/NSF Conference of Abrupt Climate Change, Grenoble, France.

Overpeck, J.T. and P.J. Bartlein. 1984. "Time series analysis of a 1000-year high-resolution pollen record from north-central Wisconsin." International Palynological Conference.

ATTACHMENT B

Contentions Adopted By **Jonathan Overpeck** In Accordance With Affidavit
NEV-SAFETY-9
NEV-SAFETY-10
NEV-SAFETY-11
NEV-SAFETY-12
NEV-SAFETY-13
NEV-SAFETY-18
NEV-SAFETY-19

Attachment 16

Affidavit of Lawrence D. Phillips

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF LAWRENCE D. PHILLIPS

I, Lawrence D. Phillips, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Lawrence D. Phillips, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Lawrence D. Phillips

Lawrence D. Phillips

The above-named affiant personally appeared before me this 6th day of December, 2008, and executed this affidavit.

Notary Public

My commission is for life

My Commission expires:____________

WILLIAM B. KENNAIR
SCRIVENER NOTARY
LONDON, ENGLAND

ATTACHMENT A

CURRICULUM VITAE

LAWRENCE D. PHILLIPS

Dr. Lawrence D. Phillips
1 Ladywell Court
22 East Heath Road
London NW3 1AH
LSE telephone: 020 7955 9101
larry_phillips@msn.com
website: www.lawrencephillips.net

Overview:

Dr. Lawrence Phillips is a Visiting Professor of Decision Sciences at the London School of Economics and a Director of Facilitations Limited. After completing an undergraduate degree in Electrical Engineering at Cornell University, he served for three years in the US Navy where he became interested in the interaction between people and machines. To pursue this, he took up post-graduate study in engineering psychology, human learning and decision making at the University of Michigan, where he studied under Professor Ward Edwards, the founder of the field of behavioural decision making. Post-doctoral research on how people in other countries take risks brought him to England, and led to an appointment at Brunel University in the newly created School of Social Sciences. There he taught Bayesian statistics, introductory psychology, observation and interviewing, social and personality psychology, decision theory and behaviour in organisations. He trained in observation and group processes at the Tavistock Clinic and Institute of Human Relations.

His early research focused on how individuals deal with risk and uncertainty. One of his discoveries, with Ward Edwards, was that people fail to become as certain as they could when faced with objective data. Then in the mid-1970s, he discovered, with George Wright, substantial East/West differences in the way people deal with uncertainty. Research then shifted to how groups of people form preferences, consider uncertainty, make judgements and take decisions, with particular emphasis on how a group can outperform even its best member.

Work with insurance underwriters in the 1970s led to developing structured methods for obtaining risk assessments from groups of interacting experts, each of whom has a different perspective on the risk. These methods have been used by various organisations, including the US Nuclear Regulatory Commission, AEA Technology, Nirex and, most recently, the Committee on Radioactive Waste Management.

Dr. Phillips created the Decision Analysis Unit at Brunel in 1974 as a self-funding research unit, which moved to the LSE in 1982. At the DAU he developed decision conferencing, a process for helping groups of key players to find solutions to complex issues of concern to their organisation. At the LSE, he teaches behavioural decision theory and decision analysis to undergraduates and post-graduates, including students enrolled in the School's MSc in Decision Sciences. He has authored 100 publications spanning organisation theory, behavioural decision theory, decision and risk analysis, Bayesian statistics, group processes and cultural differences in dealing with uncertainty. He has served on the editorial boards of *Acta Psychologica*, the *Journal of Forecasting* and the *Journal of Behavioral Decision Making*, and he is an editor of the new INFORMS journal *Decision Analysis*.

In his consultancy work, he acts as a process consultant, facilitating work groups and decision conferences, helping individuals and teams to use their differing perspectives on the issues to arrive at an agreed way forward. His expertise is in applying a wide variety of approaches, such as decision and risk analysis, scenario planning and the theory of multiple objectives, to issues of strategic and operational management, option evaluation, prioritisation, resource allocation, policy analysis, risk analysis and crisis management.

Personal Information:
- Married. Two children, Matthew and Joseph.
- Nationality: USA citizen; British resident since September 1966; British citizen
- Date of Birth: 13 June 1934
- Place of Birth: Ithaca, New York, USA
- Director, Facilitations Ltd

Fields of Interest:
- Decision making, risk taking, human judgement
- Decision and risk analysis
- Multi-criteria decision analysis
- Cultural differences in dealing with uncertainty
- Strategic management
- Bayesian statistics
- Group processes

Education:

1993:	Team Management System Accreditation Workshop, TMS Development International Ltd, 128 Holgate Road, York YO2 4DL
1988:	Tavistock Working Conference: Rethinking individual, group and organizational change in current and future contexts, Tavistock Institute of Human Relations, 120 Belsize Lane, London NW3.
1968:	Conference on the Examination of Group Behaviour, Tavistock Clinic, 120 Belsize Lane, London NW3.
1967-69:	Infant Observation Course, Tavistock Clinic.
1960-66:	University of Michigan, PhD in Psychology
1951-57:	Cornell University, BEE (Bachelor of Electrical Engineering); Certificate of Advanced Study in Electrical Engineering (MSc equivalent)
1948-51:	Ithaca High School, Ithaca, New York, USA
1945-48:	Boynton Junior High School, Ithaca, New York, USA
1939-45:	East Lawn School, Ithaca, New York, USA

Military Service:

1967-59:	Electronics Officer, USS John Paul Jones (DD 932)
1958-59:	Instructor, Officer Candidate School, Newport, Rhode Island, USA
1959-60:	Projects Officer, Destroyer Development Group 2, Newport Rhode Island, USA

Employment:

1955: Laboratory Superintendent, Cornell Aeronautical Laboratory, Buffalo, New York, USA.
1960-61: Assistant in Research, Institute of Science and Technology (IST), University of Michigan, Ann Arbor, Michigan, USA.
1963-65: Research Assistant, IST.
1965-66: Research Associate, IST; Instructor, Department of Psychology.
1966-67: Associate Research Psychologist (on leave).
1967-73: Lecturer in Psychology, Brunel University, Uxbridge, Middlesex UB8 3PH.
1973-82: Senior Lecturer in Psychology, Brunel University.
1974-82: Director, Decision Analysis Unit, Institute of Organisation and Social Studies, Brunel University.
1976-77: Senior Research Analyst, Decisions and Designs, Inc., McLean, Virginia, USA (on leave from Brunel).
1982-92: Director, Decision Analysis Unit, London School of Economics and Political Science (LSE), Houghton Street, London WC2A 2AE.
1992-94: Senior Research Fellow, LSE.
1994-present: Visiting Professor of Decision Sciences, LSE.

Professional Societies:

- American Psychological Association.
- British Psychological Society; Mathematical and Statistical Section (Chairman of the Section in 1975); Cognitive Psychology Section.
- Institute for Operations Research and the Management Sciences (INFORMS); Decision Analysis Society.
- Operational Research Society
- Judgment and Decision Making Society
- European Association for Decision Making
- International Decision Conferencing Forum (founding member)

Honours:

- Sigma Xi, The Scientific Research Society of North America
- Phi Kappa Phi (post-graduate scholastic honorary)
- Meritorious Service award from Destroyer Development Group 2, 1960
- Frank P. Ramsey award from the Decision Analysis Society for "Distinguished Contributions in Decision Analysis," November 2005

Teaching:

- University of Michigan
  Teaching Fellow for Dr Paul Fitts's course on Human Factors Engineering. Introductory Psychology for honours students. Teaching Assistant for the Department of Engineering's summer short course on Engineering Psychology.
- US Navy
  Naval Operations (over 500 hours lecturing to college and university graduates).

- Brunel University
  Bayesian statistics for social science students. Field Methods (observation and interviewing). Decision Making. Empirical Study of Social Relations. Empirical Study of Personality. Introductory Psychology. Behaviour in Organisations. Research Methods.
- Brunel Management Programme
  New Perspectives on Decision Making. Decision Analysis. Dealing with Uncertainty. Principles and Techniques of Decision Analysis. New Techniques for Decision Making. New Perspectives on Risk. Investment for Production. Managing R&D.
- London School of Economics
  Major role in the MSc in Decision Sciences. Decision Analysis in Theory and Practice. Advanced Topics in Decision Analysis. Decision Analysis in Social Context. Various guest lectures, on other LSE MSc courses, in organisation theory, group processes, risk and facilitation skills.
- Enterprise LSE
  Executive Education: Decision Making for Managers. Cardean/UNext: Quantum course on Behavioral Decision Theory; MBA course, Decision Making for Managers. BBC Decision Making Workshop.
- External courses and lectures since 1969 on decision analysis, risk analysis, Bayesian statistics, multi-attribute decision making, decision support systems, prioritisation and resource allocation in R&D, strategic management, theory and practice of facilitation, group decision making for: Glacier Institute of Management, Cranfield Institute of Technology, Brunel Management Programme, Time Sharing Ltd., The Open University, The Police College at Bramshill, The National Defence College at Latimer, The London Graduate School of Business Studies, Unilever, The Electricity Council, Commercial Union Assurance, British Petroleum, London Life Association, Nestles, Programmes Analysis Unit of the UK Atomic Energy Authority at Harwell, The International Labour Office of the United Nations, IBM, Shell International, Shell Canada, Shell Greece, Shell Turkey, General Motors, Ocean Transport and Trading, C.D. Searle, Joint Research Centre of the Commission of the European Communities, Institute of Engineering Production, Civil Service College, H.J. Heinz, Institute of Public Administration (Dublin), Sussex Constabulary, Ministry of Defence, ICL, Royal Air Force Staff College, GKN, UNICOM, Royal Statistical Society, Operational Research Society, Butler Cox, PA Computers & Telecommunications, Oasis Kelco, British Coal, CEGB, Strategic Planning Society, Warwick Business School, Kingston University, Association of Insurance and Risk Managers in Industry and Commerce (AIRMIC), EA Technology, Management Centre Europe, Curtin University, Institute of Risk Management, Management Forum, IIR Ltd., Strategic Decisions Group, The Pharmaceutical Society, University of Surrey, Medical Benefit/Risk Foundation, OECD, Drug Information Agency, Medical Decision Making Society, IFORS, Centre for Medicines Research International, Vision in Business, IQPC, UK Government Operational Research Society, Catalyze Limited courses on Value for Money, Procurement, Decision Skills: Theory and Practice, Facilitation Skills.

External Examining:
1988 - 1994
Professional Judgement course, Open University.

Consultancy:
Since 1974, I have facilitated over 200 applications of decision and risk analysis for the following 87 organisations:
Lake Pontchartrain Bridge Commission; Universal-Cyclops, Inc.; Gas Gathering Pipeline Company; ICI Pharmaceutical Division; Commercial Union Assurance Company; Decisions and Designs, Inc; The Post Office; Dashwood Underwriting Agency; British Oxygen Company; Mars Ltd; Butler Cox & Co; ICL; Insurance Technical Bureau; The Frizzel Group; Shell; CEGB; CAP-Scientific; Plessey; Smith Kline & French; British Sugar; Edwardes High Vacuum; London Life; BUPA; Dell Computer Corporation; Ciba-Geigy; Boehringer Ingelheim; International Federation of Health Funds; Lipha; Action Aid; London Lighthouse; AEA Technology; Nirex; SmithKline Beecham; Vosper Thornycroft; Glaxo; BBC; Amylin; Coopers Lybrand; DEGW; Bath College of Higher Education; Ministry of Defence; Mobil; National Audit Office; Sequent; Procter & Gamble; Upjohn; Pfizer; Eagle Star; Sun Life of Canada; Allergan; EA Technology; Yorkshire Electricity; Scottish Hydro Electric; Barnardo's; Janssen Pharmaceutica Research Foundation; Bristol-Myers Squibb; Vertex; Ministry of Agriculture, Fisheries and Foods; Pharmacia; AIG Europe; 3M; PMA Education; YARD; Department of Trade and Industry; Allied Dunbar; Barclays Life Assurance; Horizon IJVC; Astra Hässle; London School of Economics; National Economic Research Associates; F. Hoffman-La Roche; BAE Systems; DEFRA; HM Customs & Excise; Environment Agency; City University; North East London Strategic Health Authority; Jigsaw; Committee on Radioactive Waste Management; Marks & Spencer; Centre for Medicines Research International; Wyeth; Astra-Zeneca; CREATE at the University of Southern California; Egan, Fitzpatrick & Malsch, PLLC; NATO; Ontario Ministry of Health

Examples of work for public sector organisations include:

- Examination of the Department of Trade and Industry's Support for Industrial Innovation. National Audit Office report published in 1995.
  Evaluated eight schemes against 5 cost and 14 innovation criteria to show the relative cost effectiveness of the schemes.

- Prioritisation of the Innovation and Technology Support budget, for the Department of Trade and Industry.
  Prioritised 27 strategies in five areas defined by the purposes of the ITS programmes and activities, considering yearly costs and four benefit criteria, July 1995.

- Evaluation of strategies for updating the Hunt minesweeper, for the Ministry of Defence, 1995.

- Evaluation of options for an automatic landing system to winch the Merlin helicopter onto a Type 23 frigate, for the Ministry of Defence, 1995.

- Affordability study for Project Horizon, a multi-national project to design a new generation of advanced frigates,1997-8.
  MCDA was used in three 3-day working group sessions to examine the best collection of technical solutions over 21 functional areas (e.g., survivability/vulnerability, or anti-aircraft

warfare—inner layer defence system) in light of conflicting objectives associated with cost, performance, time to in-service, and risk. Naval personnel and civilian contractors from the three nations, UK, France and Italy, attended all the meetings. The decision conferencing format enabled the group to develop a shared understanding of the issues, with the result that an affordable, tentative "Preferred solution" was agreed.

- Affordability study for the Type 45 destroyer, for the Ministry of Defence, 1999.
  Used decision conferencing and MCDA modelling in a manner similar to Project Horizon. The process greatly shortened the time to final approval of the ship's design, mainly by gaining the buy-in of all the key players during the process. The approach was favourably commented on in the National Audit Commission's *Major Projects Report 2002* for the Ministry of Defence.

- Balance of Investment for the Director of Equipment Capability, Above Water Battlespace, for the Ministry of Defence, 2000.
  A project to prioritise investment on all the major equipments in this sector of the Royal Navy's procurements. Used decision conferencing and MCDA to engage all the key players and gain their commitment to the final prioritisation.

- Balance of Investment for the MoD Equipment Programme 02, 2001
  In December 2000 the Joint Capabilities Board of the MoD authorised the use of decision conferencing and MCDA modelling for prioritising all equipment procurement across the services. The JCB engaged Enterprise LSE to assist with implementing this new system. The project included training 12 MoD personnel to facilitate decision conferences and oversee MCDA modelling across all the Directorates of Equipment Capability, as well as participating in selected decision conferences. The process of decision conferencing and Equity modelling was well received, and is now institutionalised as part of the Smart Acquisition process in the JCB, providing a value-for-money prioritisation for the MoD's annual £6 billion equipment budget.

- Prioritisation of projects for the National Measurement System Directorate, 2002
  A trial to test the applicability of MCDA and decision conferencing for prioritising resource allocation to projects in the Length programme. The trial was deemed a success, and the approach is now being applied to all the projects in the NMSD's portfolio, facilitated by the DTI's Operational Research group.

- Comparison of MCDA with cost-benefit analysis for UK air quality policy, 2003
  A project jointly funded by DEFRA and the Environment Agency to assess how MCDA techniques compare with currently-employed CBA techniques employed by DEFRA, to demonstrate the benefits of using MCDA techniques as a supplement to existing processes and to identify areas of AQS work where MCDA techniques can most appropriately be used.

- Prioritisation of the Environment Agency Science Programme, 2004
  A project resulting in a value-for-money prioritisation of programmes and options across 20 areas of work in the Agency. The purpose was to establish priorities for the emerging Science Strategy.

- North East London Strategic Health Authority, 2004
  The purpose of this two-day decision conference was to examine the applicability of decision conferencing and multi-criteria modelling for prioritising programmes and strategic initiatives across the Trusts and Strategic Health Authority. The process showed how priorities could be established to provide best value-for-money, and it generated new insights as a result of the in-depth discussions provoked by the modelling process.

- Committee on Radioactive Waste Management, 2005-2006
  A multi-criteria decision analysis that appraised 14 options for the management of the United Kingdom's radioactive waste against over two dozen criteria. The is the largest public consultation exercise ever conducted in the country, with inputs to the MCDA from citizens, stakeholders and specialists. The MCDA was used by CoRWM members to help formulate their preliminary recommendations to the UK Government in April 2006.

- Naval Base Review, 2007
  Several workshops and decision conferences helped the Royal Navy to explore options for improving the cost effectiveness of its main three naval bases in the United Kingdom.

- Allied Command Transformation, NATO, 2008
  Two decision conference established a process for prioritising projects that enable NATO to perform with greater military effectivenss and interoperability.

- Ontario Ministry of Health, 2008
  A two-day decision conference explored the feasibility of using the process for prioritising investments in health care for the province of Ontario, Canada.

Publications:

1. Phillips, L.D. (1957). Machines that are human. *The Cornell Engineer, 22,* 46-49, 64.

2. Edwards, W. and L.D. Phillips (1964). *Man as transducer for probabilities in Bayesian command and control systems*, in *Human Judgement and Optimality*, G.L. Bryan and M.W. Shelley, Editors. John Wiley: New York, 360-401.

3. Edwards, W., H. Lindman, and L.D. Phillips (1965). *Emerging technologies for making decisions*, in *New Directions in Psychology, Volume 2*. New York: Holt, Rinehart and Winston, 261-325.

4. Phillips, L.D., *Some components of probabilistic inference*, (1966). Human Performance Center, University of Michigan: Ann Arbor, Michigan.

5. Phillips, L.D. and W. Edwards (1966). *Conservatism in a simple probability inference task.* Journal of Experimental Psychology, 72, 346-55.

6. Peterson, C.R. and L.D. Phillips (1966). *Revision of continuous subjective probability distributions.* IEEE Transactions on Human Factors in Electronics, HFE-7, 19-22.

7. Phillips, L.D., W.L. Hays, and W. Edwards (1966). *Conservatism in complex probabilistic inference.* IEEE Transactions on Human Factors in Electronics, HFE-7, 7-18.

8. Beach, L.R. and L.D. Phillips (1967). *Subjective probabilities inferred from estimates and bets.* Journal of Experimental Psychology, 75, 354-9.

9. Edwards, W., L.D. Phillips, W.L. Hays and B.L. Goodman (1968). *Probabilistic information processing systems: Design and evaluation.* IEEE Transactions on Systems Science and Cybernetics, SSR-4, 248-65.

10. Gustafson, D.,.W. Edwards, W. Slack and L.D. Phillips (1969). *Subjective probabilities in medical diagnosis.* IEEE Transactions on Man-Machine Systems, MNA-10.

11. Phillips, L.D. (1970). *The 'true probability' problem.* Acta Psychologica, 34, 254-264.

12. Phillips, L.D. (1973). *Bayesian Statistics for Social Scientists*. London: Thomas Nelson; (1974) New York: Thomas Crowell.

13. Phillips, L.D. (1975). *Individual and cultural differences in assessing probability*, in *Report on Conference convened by the European Research Office, London and the U.S. Army Research Instutute for the Behavioral and Social Sciences*, G. Pask, (Ed.), European Research Office: London.

14. Phillips, L.D. (1975). *East or West, home is (probably) best*, in *The Times Higher Education Supplement*. London.

15. Morris, J., S. and L.D. Phillips (1976). The Hewitt Ingot Company. In P. Moore, D. Bunn, J. Sheppard and H. Thomas (Eds.). *Case Studies in Decision Analysis*, Penguin: London.

16. Lindley, D.V. and L.D. Phillips (1976). Inference for a Bernoulli process: A Bayesian view. *The American Statistician*, 30, 112-9; reply, 182-3.

17. Allen, J.J., C.W. Kelly, L.D. Phillips and R.R. Stewart (1976). *Computer-assisted option screening and intelligence assessment: Software user's guide*. McLean, Virginia: Decisions and Designs, Inc.

18. Phillips, L.D. (1976), Three studies in probability assessment. In G. Pask (Ed.) *Report on the Second Conference convened by the European Research Office, London and the U.S. Army Rersearch Instutute for the Behavioral and Social Sciences*. London: European Research Office.

19. Barclay, S., R.V. Brown, C.W. Kelly, C.R. Peterson, L.D. Phillips and J. Selvidge, *Handbook for Decision Analysis* (1977). McLean, Virginia: Decisions and Designs, Inc.

20. Phillips, L.D. and G.N. Wright (1977). Cultural differences in viewing uncertainty and assessing probabilities. In H. Jungermann and G.de Zeeuw (Eds.) *Decision Making and Change in Human Affairs*, Dordrecht: D. Reidel, 507-515.

21. Peterson, C.R., L.D. Phillips, S. Randall, and W. H. Shawcross (1977). *Decision analysis as an element in an operational decision aiding system (Phase IV)*, McLean, Virginia: Decisions and Designs, Inc.

22. Selvidge, J. and L.D. Phillips (1977). *Deciding among bridge warning systems*, , McLean, Virginia: Decisions and Designs, Inc.

23. Phillips, L.D., C.R. Peterson, and T.W. Keelin (1978). *The value of improved forecasts of climate for agricultural decision making*. McLean, Virginia: Decisions and Designs, Inc.

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25. Phillips, L.D., *Approaches to Decision Making* (1978). Uxbridge, Middlesex: Decision Analysis Unit, Brunel University.

26. Phillips, L.D. (1978). Decisions, Decisions!, *Brunel Bulletin*. Uxbridge, Middlesex: Brunel University.

27. Wright, G. N., Phillips, L.D., Whalley, P. C., Choo, G. T., Ng, K.-O., & Tan, I. (1978). Cultural differences in probabilistic thinking. *Journal of Cross-Cultural Psychology, 9*, 285-299.

28. Wright, G.N. and L.D. Phillips (1979). Personality and probabilistic thinking: An exploratory study. *British Journal of Psychology,* 70, 295-303.

29. Phillips, L.D., *Introduction to Decision Analysis* (1979). Uxbridge, Middlesex: Decision Analysis Unit, Brunel University.

30. Wright, G.N. and L.D. Phillips (1979). Cross-cultural differences in the assessment and communication of uncertainty. *Current Anthropology*, 20, 845-6.

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ATTACHMENT B

Contentions Adopted By **Lawrence D. Phillips** In Accordance With Affidavit
NEV-SAFETY-164

Attachment 17

Affidavit of Maurice E. Morgenstein

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF MAURICE E. MORGENSTEIN

I, Maurice E. Morgenstein, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Maurice E. Morgenstein, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Maurice E. Morgenstein

The above-named affiant personally appeared before me this 11 day of December, 2008, and executed this affidavit.

FARIEDA DAVIDS
BRANCH MANAGER
Nedbank Limited
Reg No 1951/000009/06
SHOP 8 THE PASSAGE WAY
MAIN RD, HOUT BAY 7800
MAGISTERIAL DISTRICT OF WYNBERG
COMMISSIONER OF OATHS EX OFFICIO

Notary Public

My Commission expires:________________

ATTACHMENT A

CURRICULUM VITAE

MAURICE E. MORGENSTEIN

Maurice E. Morgenstein

Maury Morgenstein
memgmi@gmail.com
510-295-3216
450 S. Walnut Drive
Monmouth, OR 97361 USA

EDUCATION:

1974 Ph.D., in Geology and Geophysics, University of Hawaii.
1969 M.Sc., in Geology, Syracuse University.
1967 B.A., in Geology, Queens College, City University of New York.
New Mexico Institute of Mining and Technology, Socorro, N.M.

OVERVIEW:

Trained at Lamont Doherty Geological Observatory of Columbia University and University of Hawaii Institute of Geophysics as a Deep Sea Geological Oceanographer/Sedimentologist specializing in authigenic mineralization reactions, metallic enrichment deposits (ocean mining) and hydration reactions of volcanic glass (sideromelane). Served at sea aboard research vessels as chief scientist and chief geologist.
Taught undergraduate and graduate classes (as appropriate) at the University of California, Berkeley; Syracuse University; Utica College; University of Hawaii, Hawaii Pacific College, and Rutgers NSF summer institute for geoscience teachers: Introduction to Oceanography, Geological Oceanography, Marine Sedimentation, Introduction to Geology, Laboratory in Geology, Sedimentology, Sedimentary Geochemistry, Clay and Zeolite Mineralogy, Geoarchaeology, Provenance of Ceramics and Lithics, Optical Petrography, Archaeology of Fire, Geomorphology, Advanced Archaeological Ceramics and Field School in Geoarchaeology.

Mining geologist in deep ocean manganese nodules, terrestrial placer gold and lithium pegmatite deposits. Partner in TM& Mining Ltd based in Tanzania.

RESEARCH INTERESTS:

- Hydration of natural (obsidian and sideromelane) and man-made glass (such as borosilicate glass)
- Provenance of ceramics and chert lithic artifacts (geochemical and Petrographic studies)
- Micromorphology of soils-geochemical and physical sedimentology of sediments
- Stable isotope geographic patterns in meteoric water and plant and mammal consumers
- Neomineralization of zeolites and clays
- Development of new geochemical tools for chronology
- Isolation of High-Level Nuclear Waste
- Ocean mining (near shore and deep sea)
- Gemstone mining (metamorphic and igneous occurrences)

PRESENT POSITIONS:

President, Geosciences Management International, Inc. (GMI, Inc.) 450 S. Walnut Drive, Monmouth, OR 97361 USA

Adjunct Research Professor, Department of Archaeology, University of Cape Town, (UCT), Cape Town, South Africa

Adjunct Professor, Near Eastern Studies Department, 250 Barrows Hall, University of California, Berkeley 94720-1940, USA

Co-Director, El-Hibeh Project, Egypt, University of California, Berkeley
http://neareastern.berkeley.edu/hibeh/explore.htm

Member, Archaeological Research Facility, University of California, Berkeley

Partner, TM& Mining Ltd., Tanzania

ACADEMIC CLASSES TAUGHT WITHIN LAST 36 MONTHS (at University of California, Berkeley):

Graduate Seminar Spring 2005- NES Department, Pottery – Co–Taught with Prof Carol Redmount
Graduate Seminar Fall 2005 – NES Department, Archaeology of Fire
Graduate Class Fall 2005 – NES Department, Optical Petrography for Archaeologists
Graduate Seminar Spring 2006 – NES Department, Geochemistry and Petrography as Applied to Provenance Studies (Advanced Pottery Seminar)

PROFESSIONAL GEOLOGICAL ARCHAEOLOGY EXPERIENCE:

2008-Present	Adjunct Research Professor, Department of Archaeology, UCT
2007-Present	Geoarchaeologist, Morgantina, Sicily
2006-Present	Partner and Senior Geologist, Metamorphic gemstone mining, Tanzania
2005-Present	Adjunct Professor, Near Eastern Studies Department, University of California, Berkeley
2000-Present	Co-Director and Geoarchaeologist, El-Hibeh Project, Egypt, University of California, Berkeley
1998-2003	Visiting Scholar, Archaeological Research Facility, University of Cal., Berkeley
2004-2005	Visiting Scholar, Eastern Studies Department, University of California, Berkeley
1998-2002	Geoarchaeologist, Nemea Project, Greece, University of California, Berkeley.
1993-2000	Geoarchaeologist, Tel l el-Muqdam Project, Egypt, Univ. of Cal., Berkeley.
1993-1997	Geoarchaeologist, Consultant to State Parks, Research Fellowship, Utah. Humanities Council via Utah State Parks, Anasazi State Park, Coomb's Site.
1992-2003	Geoarchaeologist, BOAS, Inc., Seattle, WA.

1991-Present	President and Geoarchaeologist, Geosciences Management Institute, Inc. (GMI), Boulder City, Nevada.
1974-1982	President and Geoarchaeologist, Hawaii Marine Research, Corporation, Honolulu, Hawaii.
1976-1979	Affiliate Faculty of the Graduate School of the University of Hawaii. (Anthropology Department, Geoarchaeology).
1977	Consultant - Historic Building Materials Restoration, and Geoarchaeology, State of Hawaii, Department of Land and Natural Resources, Division of State Parks.
1969-1976	Consultant, geoarchaeologist, Pacific Basin.

OTHER EXPERIENCE:

1993-1998	Magnetic Survey Geophysics and Nile Delta Coring Program, Tell el-Muqdam Project Geologist - Geophysicist, Egypt, University of California, Berkeley.
1992-1998	Geophysics - EM, Ground Radar, and Magnetics, Geophysicist, BOAS, Inc., Seattle, WA.
1991-1998	Sedimentologist, Mineralogist, Geosciences Management Institute, Inc. (GMI), Boulder City, Nevada.
1982-1984	Senior Geologist, Geophysicist, Director of Operations, Gold Mine, Brim Partnership, Lake Havasu, Arizona.
1974-1982	Seismic Geophysicist, Hawaii Marine Research, Corporation, Honolulu, Hawaii.
1974-1982	Ocean Mining Geologist, Hawaii Marine Research, Corporation, Honolulu, Hi.
1974-1975	Assistant Researcher, Research Corporation of the University of Hawaii.
1965-1969	Chief Geologist - R/V Conrad, Lamont-Doherty Geological Observatory of Columbia University.
1964-1969	Assistant in Research, Lamont-Doherty Geological Observatory of Columbia Univ.
1975	Assistant Oceanographer, University of Hawaii.
1973-1975	Ferromanganese Program Coordinator, State Program, University of Hawaii.
1972-1974	Research Assistant, Research Corporation of the University of Hawaii.
1970-1974	Chief Scientist - R/V Teritu and R/V Kana Keoke.
1969-1972	Assistant in Geophysics, University of Hawaii.
1964-1969	Assistant in Research, Lamont-Doherty Geological Observatory of Columbia University.
1971&1972	Lecturer - Hawaii Pacific College and University of Hawaii (Geological Oceanography).
1967-1969	Teaching Assistant - Syracuse University (Geology); Lecturer Utica College (Geology).
1967	Lecturer - Department of Geology, Rutgers University, NSF Summer Institute.

SELECTED PUBLICATIONS:

Emery, V. L. and M. Morgenstein. 2007. Portable EDXRF Analysis of a Mud Brick Necropolis Enclosure: Evidence of Work Organization, El-Hibeh Middle Egypt, Journal Arch. Sci.34, 111-122.

Pulvirenti, A. L., K. M. Needham, M. A. Adel-Hadadi, C. R. Marks, J. A. Gorman, M. E. Morgenstein, D. L. Shettel and A. Barkatt. In Press. Acid Generation upon Thermal Concentration of Natural Water: The Effects of Ionic Composition and Critical Water Content. Applied Geochem.

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Morgenstein, M., and W. Latady, 1997. Proveniencing Intrusive, Trade and Local Pottery by Magnetic Susceptibility Measurements, Geochemical and Petrographic Analysis: The Coombs Site, 42GA34. Learning from the Land: The Grand Staircase-Escalante Natural Science Symposium, Nov. 1-5, 1997, Proceedings.

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Morgenstein, M, 2000. Micromorphological Characterization and Microstratigraphic Interpretation of a Mid-Holocene Site, 45-KI-464, in the Western Cascade Foothills. Abstract: SAA 65th Annual Meeting, April 5-9, 2000

Morgenstein, M., 2000. Chert Provenance Analysis at a Mid-Holocene Site, 45-KI-464, in the Western Cascade Foothills, King County, Washington. Abstract: SAA 65th Annual Meeting, April 5-9, 2000

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Selected Nuclear Waste Presentations:

Morgenstein, 2006 (September) United States Nuclear Waste Technical Review Board, Workshop on Localized Corrosion of Alloy 22 in Yucca Mountain Environments, Las Vegas, Nevada

Morgenstein, 2005 (June) Nuclear Regulatory Commission, Advisory Committee on Nuclear Waste, 151st ACNW meeting, Rockville, Maryland

Morgenstein, 2003 (March) Nuclear Regulatory Commission, Advisory Committee on Reactor Safeguards 140th meeting, Rockville, Maryland

Morgenstein, 2000 (October) Nuclear Regulatory Commission, Advisory Committee on Nuclear Waste (ACNW), Rockville, Maryland

Patents:

2 U.S. Patents in Deep-Sea Mining Equipment:

1) Morgenstein, M., May 11, 1976. Elevator apparatus for towed deep-sea particle harvester, U.S. Patent 3,955,294.
2) Andrews, J. E. and M. Morgenstein, April 6, 1976. Process and apparatus for deep-sea particle harvesting, U.S. Patent 3,947,980.

ATTACHMENT B

Contentions Adopted By **Maurice E. Morgenstein** In Accordance With Affidavit
NEV-SAFETY-43
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Attachment 18

Affidavit of Robert A. Cottis

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of U.S. DEPARTMENT OF ENERGY License Application to Construct a Geologic Repository at Yucca Mountain	)	Docket No. 63-001

AFFIDAVIT OF ROBERT A. COTTIS

I, Robert A. Cottis, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Robert A. Cottis, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

R.A. Cottis
Robert A. Cottis

The above-named affiant personally appeared before me this 11th day of December, 2008, and executed this affidavit.

[signature]
Notary Public MANCHESTER U.K.

My Commission ~~expires.~~ CONTINUES SO LONG AS I SHALL PRACTICE

ATTACHMENT A

CURRICULUM VITAE

ROBERT A. COTTIS

Curriculum Vitae - Robert Alan Cottis

Personal Record

Date of Birth		18th April 1946
Place of Birth		Epping, England
Nationality		British
Marital Status		Married, 3 children
Home address		42, Clement Road, Marple Bridge, Stockport SK6 5AG. Tel. 016-449-8593
Secondary education	1957-64	Forest School, Snaresbrook.
University education	1964-67	Gonville and Caius College, Cambridge. Natural Sciences Tripos Part I - First Nat. Sciences Tripos Pt. II (Metallurgy) - First
	1967-70	Gonville and Caius College, Cambridge and Department of Metallurgy and Materials Science (postgraduate research).
Degrees awarded	1967	BA (Hons), 1st class, University of Cambridge
	1970	MA, University of Cambridge.
	1973	PhD, University of Cambridge.
Scholarships	1963-67	Scholar, Gonville and Caius College.
	1967-70	Rhonda Studentship, Gonville and Caius College.
PhD thesis	1973	"Metal Deposition in the Fluidized Bed Electrode"
Present position	1978-	Lecturer then Senior Lecturer (1992-) and Reader (2000-) in Corrosion Science and Engineering, Corrosion and Protection Centre, UMIST, then the University of Manchester.
Previous employment	1970-78	Project Manager, then (1973) Research Manager, Fulmer Research Institute, Stoke Poges, Bucks.
Visiting Appointments	2002-	Visiting Professor, 1st Class, University of Burgundy, Dijon.

B - Teaching and Learning

B1 Current teaching duties:

MSc Course in Corrosion Science and Engineering (20-30 students)

Corrosion Chemistry and Electrochemistry (part, 18 hours)
Localized and Mechanical Aspects of Corrosion (part, 2 hour)
Corrosion Control by Materials Selection, Surface Engineering and Corrosion Testing (part, 12 hours)

B2 Other teaching

Internal service teaching (none taught currently):

MSc Course in Terotechnology (later Maintenance Management and Engineering)
Mechanical Metallurgy (10 hours)
Principles of Corrosion (10 hours)

Chemical Engineering 3rd Year Materials Option
Mechanical Metallurgy (9 hours)
Corrosion (9 hours)

Civil and Structural Engineering 2nd/3rd Year (~60 students)
Introduction to Corrosion (8 lectures)

MSc Course in Civil and Structural Engineering (5-15 students)
Introduction to Corrosion (9 lectures)

Metallurgy Undergraduate Course, 3rd year
Hydrogen Embrittlement and Corrosion Fatigue (3 lectures)

Continuing education:

Departmental Short Course Organizer (1982-86).

Regular contributions to 'Corrosion Control' short courses (5 days), both in Manchester (typically once per year) and overseas (including Philips Petroleum, Stavanger, Kuwait Petroleum Corporation, Kuwait, Kuala-Lumpur, Abu Dhabi and Bahrain).

Co-organizer and lecturer to 'Stress-Corrosion in Plant and Structures' (3 days, 1985).

B3 Publications related to teaching

(1)	S.E. Faidi, M. Fay and R.A. Cottis	The Use of Multimedia in the Teaching of Corrosion, *Proc. 13th International Corrosion Congress,* Melbourne, November 1996.
(2)	S.E. Faidi, M. Fay and R.A. Cottis	"A Computer Aided Learning Package for Teaching Corrosion to Engineering Students", Corrosion/96, Paper No 377, NACE 1996.
(3)	R.A. Cottis, A-M. McAllister and W. David	"Online delivery and tutor support of an introductory corrosion course", Corrosion/2004, Paper 69, 2004.
(4)	W. Bogaerts, R.A. Cottis, S.B. Lyon, P. McIntyre, M. Piens, G. Pimenta, P. Poh and Thuy Vuthi	"Mentor-C – a Resource for Corrosion Education", Paper 687, Eurocorr 2005, Lisbon, September 2005.
(5)	R.A. Cottis	"A Low-Cost Computerised Electrochemistry System for Corrosion Teaching", Eurocorr, Maastricht, September 2006

B4 Innovative work and contributions to curriculum reform and development

I have played a significant part in the introduction of case study teaching methods in the Centre, and have been responsible for a number of failure investigation and other exercises.

I have also been concerned with the introduction of several aspects of computer technology into teaching. This has included the introduction of computer-aided preparation of visual aids, and the provision of computing facilities for dissertation and doctoral research.

I was Project Director for the Ecorr (Engineering Corrosion) TLTP project that developed a series of CAL modules to support the teaching of corrosion to engineering undergraduates.

I was responsible for the successful reorganization of the MSc Course into 'short-fat' modules, and the structuring of these modules to facilitate part-time attendance.

I was responsible (with Professor Thompson) for the preparation of the successful bid to EPSRC for the Masters Training Package in Corrosion Control Engineering. This provided £ k for the development of the Course.

In 2001 I studied the application of computer-based formative assessment to Masters level teaching with the support of a Teaching Research Fellowship. This has been disseminated through a TaLSC Workshop.

I am currently responsible, as MSc Course Development Director, for the introduction of distance learning routes for this course.

In 2002-3 the initial delivery of the first distance learning module was supported by an award from the Curriculum Innovation Fund to support the development and trialling of a tutor training course, which is now a standard university course.

I was a member of the Management Board of GLOW (Graduate Learning on the Web).

B5 Examination responsibilities

Responsible for preparation and marking of examination questions for all courses taught, and member of appropriate Boards of Examiners (formerly Chemical Engineering BSc, Civil and Structural Engineering BSc and MSc Courses and Corrosion Science and Engineering MSc, currently Corrosion Control Engineering MSc).

B6 Results of Assessment of Teaching

One of my lectures was assessed during the QAA Teaching Assessment, and it was found to be at the highest level. Student teaching assessment scores have generally been in the region of 3-4 out of 5; however, the recent offering of the difficult and normally poorly rated Unit 2 (the first to build on the distance learning material) has received very positive comments from students, and, more significantly, an increase in average examination mark of the order of 10%. This has convinced me of the major benefits to be gained from the application of e-Learning techniques for both on-campus and distance students.

B7 Appointments held as Course Director or Tutor

Development Director, MSc in Corrosion Control Engineering (2000-); responsible for the production of a distance learning version of the course.

I am chair of the School Working Party on e-Learning.

B8 Voluntary Activities with Students

Pastoral tutor for MSc course students (around four per year).

I trialled a PASS scheme with the MSc in the period 1999-2002, using PhD students as mentors. This was eventually abandoned due to difficulties in accommodating it in a very busy timetable, and the lack of sufficient time in the taught component of the course to induce the students in the process. However, it convinced me of the benefits of the merits of student mentoring, and lead to the use of research students as tutors for the distance learning version of the course, which has proved very successful.

B9 Statement on Teaching

I have been very active in the development of teaching and learning, particularly in recent years, when I have been leading the reorganization of the MSc Course into a modular format, and the development of a distance learning version of course modules, with EPSRC MTP funding. As well as providing a new route to the degree, the e-Learning techniques used have demonstrated very significant benefits for campus-based students; subject to the approval of the School's CTA bid, I would hope to help extend the application of e-Learning to other components of the Manchester Materials Masters programme and to undergraduate programmes.

Teachings loads in a research-oriented postgraduate centre are inevitably low by comparison to undergraduate departments; in the past I have usually had one of the highest teaching loads in the Corrosion and Protection Centre. However, in recent years this has reduced somewhat as I have concentrated on the development of the distance learning version of the course.

I have also taught a number of introductory corrosion courses to students in other departments, and I have been a regular contributor to short courses, both in Manchester and elsewhere.

In respect of the administration of teaching, I have been an active member of the Teaching and Learning Committee, member of the internal programme review committees for the Departments of Chemical Engineering and Textiles and Paper, and I prepared the Centre's documentation for its programme review.

C - Research and Academic/Professional Standing

C1 Publications

In my employment at Fulmer Research Institute I was engaged almost exclusively in work for the Ministry of Defence, which was subject to the Official Secrets Act, or for commercial sponsors who required confidentiality. Therefore I was not able to publish in the open literature during this period. However I was responsible for numerous technical reports in this period (I do not have a detailed record, but I would estimate that the total would be in the region of 150, with about 20% being reports on major research projects, the remainder being on smaller research projects or failure investigations).

In addition to the more conventional publications discussed below I am the founder, with Dr M.W. Kendig of the Rockwell International Science Centre, of CORROS-L, the first international electronic mailing list for corrosion and related subjects, currently hosted on the JISCMail List Server (http://www.jiscmail.ac.uk), and with list members around the world. I am also founding editor of the open access electronic Journal of Corrosion Science and Engineering, sponsored by the International Corrosion Council (http://www.jcse.org).

Authored Books

(6)	R.A. Cottis and R.C. Newman	"Stress Corrosion Cracking Resistance of Duplex Stainless Steels", *OTH*, **94**, 440, 44p, HSE Books (1995), ISBN 0 7176 0915 4.
(7)	S. Turgoose and R.A. Cottis	Corrosion Testing Made Easy - Electrochemical Impedance and Electrochemical Noise, NACE, ISBN 1-57590-093-9, 149p March 2000.
(8)	R.A. Cottis	"Guide to Good Practice in Corrosion Control : Stress-Corrosion Cracking", 11p, HMSO, 2000 (also available online at http://www.npl.co.uk/materials/ncs/docs/stress.pdf).

Edited Books

(9)	P.A. Scott and R.A. Cottis (editors)	"Environment-Assisted Fracture", I.Mech.E, 510p, (1990)

Edited Works: Contributions

(10)	R.A. Cottis, K. Farrow and J. Hutchings	"The Fulmer Materials Optimizer - Corrosion Section", pub. Fulmer Research Institute (1974). This is a compilation of materials properties for the design engineer. The corrosion component was distributed through the book, but probably totalled about 80 pages.
(11)	R.A. Cottis	"Stress-Corrosion Cracking of High Tensile Steels", Chapter 8.4 in Corrosion, eds. L.L. Shreir, R.A. Jarman and G.T. Burstein (pp8.84-8.114) (1994).
(12)	R.A. Cottis	"Electrochemical Noise for Corrosion Monitoring", in Chapter 4 in Techniques for Corrosion Monitoring, ed Lietai Yang, (pp. 86-109), Woodhead Publishing (2008).

Conference contributions: refereed

(13)	R.A. Cottis and Z. Husain	"The Role of Inclusions in Corrosion Fatigue Initiation in a Maraging Steel", *Proc. 8th Internat. Cong. on Metallic Corrosion*, Mainz, Dechema, pp467-472, 1981.
(14)	A. Alavi and R.A. Cottis	"The Measurement of pH and Chloride Concentration in a Simulated Crevice", "*Embrittlement by the Localized Crack Environment*", ed. R.P. Gangloff, pp75-88, TMS-AIME, Philadelphia, 1983.
(15)	R.A Cottis, A. Alavi, R.D. Eden and J.D. Scantlebury	"Polarity Reversal and Protection of Crevicing Mild Steel in Sodium Chloride Solutions", *Corrosion Chemistry within Pits, Crevices and Cracks*, ed. A. Turnbull, pp471-482, NPL, London, 1984.
(16)	E.A. Taqi and R.A. Cottis	"The Influence of Crevice Conditions on the Uptake of Hydrogen by Steel", *Corrosion Chemistry Within Pits, Crevices and Cracks*, ed. A. Turnbull, pp483-494, N.P.L., London, 1984.
(17)	Z. Husain and R.A. Cottis	"The Influence of Seawater Corrosion and Mechanical Damage on the Fatigue Endurance of Wire Rope", *Endurance Research of Wire Rope and its Practical Applications*, OIPEEC, 1985.

(18)	R.A. Cottis	"The Corrosion Fatigue of Steels in Saline Environments: Short Cracks and Crack Initiation Aspects", *Small Fatigue Cracks*, ed. R.O. Ritchie and J. Lankford, TMS-AIME, pp265-268, 1986.
(19)	Z. Husain and R.A. Cottis	"The Influence of Seawater Corrosion on the Fatigue Strength of Steel Wire Rope", *Proc. Conf. Fatigue of Engineering Materials and Structures*, I.Mech.E., Sheffield, pp387-392, 1986.
(20)	R.A. Cottis, E.A. Taqi and M. Haji-Ghassemi	"The Influence of Crack Conditions on Hydrogen Uptake by Steel", *Fatigue 87*, Vol.III, pp1179-1188, Charlottesville (1987).
(21)	R.A. Cottis and A. Markfield	"The Role of Inclusions in Corrosion Fatigue Crack Initiation in Q1N", *Fatigue 87*, Vol.I, pp597-586, (1987).
(22)	R.A. Cottis, A. Markfield and P. Haritopoulos	"The Role of Corrosion in the Initiation and Growth of Corrosion Fatigue Cracks", *Environment-Assisted Fatigue*, eds P.A. Scott and R.A. Cottis, I.Mech.E., pp381-394 (1990)
(23)	R.A. Cottis and S. Turgoose	"Linear Electrochemical Methods", *Electrochemical and Optical Techniques for the Study and Monitoring of Metallic Corrosion*, eds. M.G.S. Ferreira and C.A. Melendres, NATO ASI E203, Kluwer, pp123-133 (1991)
(24)	D.C. Buxton, R.A. Cottis and P.A. Scarf	"Life Prediction in Corrosion Fatigue", *Life Prediction of Corrodible Structures*, NACE, Kaui, November 1991.
(25)	R.C. Newman, Q. Song, R.A. Cottis and K. Sieradzki	"Atomistic Computer Simulation of Alloy Corrosion", *Computer Modelling for Corrosion*, ed. R.S. Munn, ASTM STP-1154, pp17-27 (1992).
(26)	S. Turgoose, R.A. Cottis and K. Lawson	"Modelling of Electrode Processes and Surface Chemistry in Carbon Dioxide-Containing Systems", *Computer Modelling for Corrosion*, ASTM STP, 1154, pp67-81 (1992)
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(46)	R.A. Cottis, G. Owen and M. Turega	"Prediction of the Corrosion Rate of Steel in Seawater Using Neural Network Methods", Paper 00489, Corrosion/2000, Orlando, NACE, March 2000.
(47)	R.A. Cottis	"Parameters for the Identification of Localized Corrosion: Theoretical Analysis", Electrochemical Society Proceedings PV 2001-22, pp 254-263 (2001)
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(49)	A. Aballe, R.C. Newman and R.A. Cottis	"Electrochemical Noise Study of Stress Corrosion Cracking of Sensitized 304H in Thiosulfate", NACE Corrosion 2003 Paper 03403 (2003)
(50)	R.A. Cottis, Murali Kumaraguru and M. Marti	"Combined Measurement of Electrochemical Noise and Electrochemical Impedance", NACE Corrosion 2003 Paper 03402
(51)	G. John and R.A. Cottis	"Laboratory Testing and Computer Modeling of the Performance of Sacrificial Anodes for use in Reinforced Concrete Structures", NACE Corrosion 2003 Paper 03302
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(55)	A.A.M. Gebril and R.A. Cottis	"The use of electrochemical noise to detect initiation of stress corrosion cracking", Corrosion/2005, Paper 05366 (2005).
(56)	R.A. Cottis and S.B. Lyon	"Modeling of Image Formation and Image Enhancement for Scanning Electrochemical Methods", Corrosion/2005, Paper 05056 (2005).
(57)	R.A. Cottis	"An Evaluation of Electrochemical Noise for the Estimation of Corrosion Rate and Type", Paper 06432, Corrosion 2006, San Diego (2006).

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(60)	S. Nwaonu, A. M.M. Gebril and R. A. Cottis	"Wavelet Analysis of EN Data", Paper 07457, Corrosion 2007, Nashville (2007)
(61)	Maftah H. Alkathafi and Robert A. Cottis	"Modelling of Carbonate-Bicarbonate Stress Corrosion Cracking of Pipeline Steels", Paper 08265, Corrosion 2008, New Orleans (2008)
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(63)	D. Holt and R.A. Cottis	"The Effect of Trace Sulphur Compounds on the Pitting of Austenitic Stainless Steels in Potable Water", *Proc. 9th International Congress on Metallic Corrosion*, Vol. 3, pp614-617, Toronto (1984).
(64)	R.A. Cottis, D.C.A. Moore, E.G. Leitch and E.G. Bellinger	"Hydrogen Uptake by Steel Under Marine Fouling Growths", *Proc. 9th International Congress on Metallic Corrosion*, Vol. 4, pp538-544, Toronto (1984).
(65)	R.A. Cottis, J.W. Johnston and R.P.M. Procter	"Effect of Tempering Temperature on Stress Corrosion Cracking of Mining Chain Steels", *Proc. Electrochemical Society Fall Meeting*, Honolulu, October 1987.
(66)	R.A. Cottis, R.C. Newman and S. Turgoose	"The Application of Computer Modelling Techniques in Corrosion Science and Technology", *UK Corrosion 89*, **1**, pp27-32, I.Corr.S.T. Leighton Buzzard (1989).
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(69)	R.A. Cottis, P.J. Laycock, D. Holt, S.A. Moir and P. Scarf	"The Statistics of Pitting Corrosion of Austenitic Stainless Steels in Chloride Solutions", *Advances in Localized Corrosion*, ed. H.S. Isaacs, NACE-9, Houston, pp117-121 (1990)

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(71)	R.A. Cottis and D.A. Buxton	"Crack Initiation in Corrosion Fatigue", *UK Corrosion 91*, **Vol. 1,** 12p, 1991
(72)	S. Turgoose and R.A. Cottis	"Modelling of Electrode Processes and Surface Chemistry in CO_2", *Proceedings UK Corrosion 91* vol 1 (1991).
(73)	M. Schofield, R. Bradshaw and R.A. Cottis	"Stress-Corrosion Cracking of Welded Duplex Stainless Steels", proceedings of "Duplex Stainless Steels 94", Glasgow, November 1994.
(74)	D. Sargeant, R. Bradshaw, M.I. Walker and R.A. Cottis	"Investigation of the Effects of Arc Strikes on Duplex Stainless Steel Using Scanning Reference Electrode Techniques", proceedings of "Duplex Stainless Steels 94", Glasgow, November 1994.
(75)	R. Bradshaw and R.A. Cottis	"The Effect of Nitrogen Additions to Argon Shielding Gases on the Properties of Duplex Stainless Steel GTA Welds", proceedings of "Duplex Stainless Steels 94", Glasgow, November 1994.
(76)	M.S. Al-Ansari and R.A. Cottis	Long-Term Monitoring of Electrochemical Noise, *Proc. 13th International Corrosion Congress,* Melbourne, November 1996.
(77)	Li Qing and R.A. Cottis	Crack Initiation Processes in the Corrosion Fatigue of Copper in Active Corrosion Conditions, *Proc. 13th International Corrosion Congress,* Melbourne, November 1996.
(78)	H.A. Al-Mazeedi, R.A. Cottis and S.Turgoose	"Electrochemical Noise Analysis of Carbon Steel in Sodium Chloride Solution with Sodium Nitrite as an Inhibitor", Proceedings of Eurocorr 2000, Institute of Materials, London, 2000
(79)	R.A. Cottis and S.B. Lyon	"Error Sources and Image Enhancement in Scanning Electrode and Related Techniques", Paper 517, Eurocorr 2005, Lisbon, September 2005.
(80)	R.A. Cottis	"Electrochemical Noise as a Technique for Corrosion Monitoring", Proceedings of CorCon 2005, Chennai, November 2005, NACE-India Section (2005).
(81)	R.A. Cottis	"An XML Format for Electrochemical Noise Data", Eurocorr 2006, Masstricht, September 2006.

Editorships: Journal

Editor in Chief, Journal of Corrosion Science and Engineering

Academic Journal Papers

(82)	R.A. Cottis, A.J. Aylward and P. Crowe	"The E78 Bus", *Euromicro Journal*, **6**, pp2-9, March 1980.
(83)	R.A. Cottis and Z. Husain	"Corrosion Fatigue Initiation Processes in a Maraging Steel", *Metals Technology*, **9**, pp104-108 (1982).
(84)	T. Alp, Z. Husain and R.A. Cottis	"Corrosion Fatigue Crack Initiation and Growth in 18 Ni Maraging Steel", *J. Materials Science*, **21**, pp3263-3268 (1986).
(85)	R.A. Cottis and C.A. Loto	"Electrochemical Noise Generation During Stress Corrosion Cracking", *Materials Science Forum*, Vol. 8, pp201-213, 1986.
(86)	R.A. Cottis, K.R. Gowers, M. Haji-Ghassemi and E.A. Taqi	"The Application of Hydrogen Permeation Measurements to the Study of Corrosion Fatigue Crack Growth in Steels", *Materials Science Forum*, Vol. 8, pp243-252, 1986.
(87)	R.A. Cottis and D. Holt	"A Semi-Automatic Device for the Rapid Measurement of Pit Depth and Position", *Corrosion Science*, **26** (1), pp103-106 (1987).
(88)	C.A. Loto and R.A. Cottis	"Electrochemical Noise Generation during Stress Corrosion Cracking of Alpha Brass", *Corrosion*, **43**, 8, pp499-504 (1987).
(89)	A. Oni, R.A. Cottis and G.E. Thompson	"Estimation of Electroless Metal Deposition Rate from Measured Bath Potential", *Trans. IMF*, **65**, pp105-107, (1987).
(90)	A. Alavi and R.A. Cottis	"Semi-micro pH Electrodes based on Quinhydrone and Related Systems", *British Corrosion Journal*, **22**, 4, pp259-263, (1987).
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(93)	C.A. Loto and R.A. Cottis	"Electrochemical Noise Generation During Corrosion of Stainless Steel Type 316 in Acid Chloride Environment", *Bull. Electrochem.*, **4** 12, pp1001-1005, 1988.
(94)	U.W. Obuzor, K.R. Gowers and R.A. Cottis	"The Effect of Marine Fouling on Hydrogen Uptake by Steel", *Microbial Corrosion - 1*, pp53-65, (1988).
(95)	R.A. Cottis	"A Low Cost Computer-Controlled Electrochemical Measurement System for Education and Research", *Materials Science Forum*, Vol. 44/45, pp123-137, (1989).
(96)	C.A. Loto and R.A. Cottis	"Electrochemical Noise Generation during SCC of High Strength Aluminium Alloy 7075 T6", *Corrosion*, **45**, 2, pp136-141, 1989.

(97)	Song Qian, R.C. Newman, R.A. Cottis and K. Sieradzki	"Computer Simulation of Alloy Passivation and Activation", *Corrosion Science*, **31**, pp621-626 (1990).
(98)	R.A. Cottis and C.A. Loto	"Electrochemical Noise Generation during Stress-Corrosion Cracking of a High Strength Carbon Steel", *Corrosion*, **46**, pp12-19 (1990).
(99)	P.J. Laycock, R.A. Cottis and P. Scarf	"Extrapolation of Extreme Pit Depths in Space and Time", *J. Electrochemical Society*, **137**, pp64-69 (1990).
(100)	Song Qian, R.C. Newman, R.A. Cottis and K. Sieradzki	"Validation of a Percolation Model for Passivation of Fe-Cr Alloys : 2-Dimensional Computer Simulation", *J. Electrochem. Soc.*, **137**, 2, pp435-439 (1990).
(101)	P.A. Scarf, R.A. Cottis and P.J. Laycock	"Extrapolation of Extreme Pit Depths in Space and Time using the *r* Deepest Pit Depths", *J. Electrochem. Soc.*, **139**, 9, pp2621-2627 (1992).
(102)	M. Haji-Ghassemi, R.A. Cottis, K.R. Gowers and J.D. Scantlebury	"Hydrogen Permeation Measurements on Lacquer-Coated Mild Steel under Cathodic Polarisation in Sodium Chloride Solution", *Journal of Oil and Colour Chemicals Association*, **75(7)**, pp277-280, (1992).
(103)	R.A. Cottis and S. Turgoose	"The Estimation of Corrosion Rate from AC Impedance Measurements", *Materials Science Forum*, Vol **111-112**, pp269-280 (1992).
(104)	A. Boukerrou and R.A. Cottis	"Crack Initiation in the Corrosion Fatigue of Structural Steels in Salt Solutions", *Corrosion Science*, **35**, pp577-585 (1993).
(105)	R. Bradshaw and R.A. Cottis	"Development and Control of Welding Procedures for Duplex Stainless Steels", *Welding and Metal Fabrications*, **6**, 3, pp129-136 (1993).
(106)	Faidi, S.B. Lyon, R.A. Cottis and K.R. Baldwin	"Non-destructive Testing Using Electromagnetic Impedance Spectroscopy Techniques", *Corrosion Science*, **35**, pp833-839 (1993).
(107)	R.A. Cottis and S. Turgoose	"Electrochemical Noise Measurements : A Theoretical Basis", *Material Science Forum,* **192-194**, pp663-672 (1995).
(108)	M.J. Schofield, R. Bradshaw and R.A. Cottis	"Stress-Corrosion Cracking of Duplex Stainless Steel Weldments in Sour Conditions", *Materials Performance*, **35**, pp65-70, April 1996.
(109)	R.A. Cottis, M.A. Al-Ansari, G. Bagley and A. Pettiti	"Electrochemical Noise Measurements for Corrosion Studies", *Materials Science Forum*, **289-292**, pp741-754 (1998).

(110)	R.A. Cottis, Li Qing, G. Owen, S.J. Gartland, I.A. Helliwell and M. Turega	"Neural Networks for Corrosion Data Reduction", *Materials and Design*, **20**, 4, pp169-178 (1999)
(111)	S.B. Lyon, J. Cai and R.A. Cottis	"Phenomenological Modelling of Atmospheric Corrosion Using an Artificial Neural Network", *Corrosion Science*, **41**, 10, pp 2001-2030 (1999).
(112)	R.A. Cottis, M.A.A. Al-Awadhi, H. Al-Mazeedi and S. Turgoose	"Measures for the Detection of Localized Corrosion with Electrochemical Noise", *Electrochimica Acta*, **46**, 24-25, pp 3665-3674 (2001).
(113)	M.A.A. Al-Mazeedi and R.A. Cottis	"A Practical Evaluation of Electrochemical Noise Parameters as Indicators of Corrosion Type", *Electrochimica Acta*, **49**, pp 2787-2793 (2004).
(114)	J.M. Sanchez-Amaya, R.A. Cottis and F.J. Botana	"Shot noise and statistical parameters for the estimation of corrosion mechanisms", Corrosion Science **47,** 12, pp 3280-3299 (2005).
(115)	R.A. Cottis	"Sources of Electrochemical Noise in Corroding Systems", *Russian Journal of Electrochemistry*, **42**, 5, pp 497-505 May 2006.
(116)	B. Vuillemin, R. Oltra, D. Crusset and R.A. Cottis	"Consideration of the formation of solids and gases in steady state modelling of crevice corrosion propagation", *Electrochimica Acta,* Volume 52, Issue 27, 10 October 2007, Pages 7570-7576.
(117)	R.A. Cottis	"The Significance of Electrochemical Noise Measurements on Asymmetric Electrodes", *Electrochimica Acta,* Volume 52, Issue 27, 10 October 2007, Pages 7585-7589.

Popular Journal Papers

(118)	R.A. Cottis	"Reducing the Cost of Corrosion", *Maintenance Engineering*, Mar/Apr 1974.
(119)	R.A. Cottis, D. Howland and P. Crowe	"E78 - The Europa Bus", *Personal Computer World*, **1**, 2 (1978).
(120)	R.A. Cottis and M. Blandford	"A High Speed Cassette Interface", *Personal Computer World*, **1**, 8 (1978)
(121)	R.A. Cottis	"Corrosion is not a Problem - but the Cost of Corrosion is", *Metallurgia*, **49**, 2, pp76-80, February 1982.

(122)	C.A. Loto and R.A. Cottis	"Electrochemical Noise Generation during Stress Corrosion Cracking of High Strength Carbon Steel - II - Maximum Entropy Method", *The Nigerian Engineer*, Nigerian Society of Engineers, **23** 2, pp1-14, 1988.
(123)	R.A. Cottis	"Listening in to Corrosion", Materials World, **7**, 8, pp482-483, July 1999.

Review Articles

(124)	R.A. Cottis	"The Interpretation of Electrochemical Noise Data", Invited Review with 78 references, *Corrosion*, 27, 3, 265-285 (2001).

Patents

(125)	L.C. Knight, D.A. Cash, D. Stewart, R.A. Cottis, W.H. Bowyer, R.C. Newnham, F.J. Williams, D.W. Pardon	"Firing range", US Patent 4281241 (filed 22 June 1979, granted 28 July 1981).
(126)	L.C. Knight, D.A. Cash, D. Stewart, R.A. Cottis, W.H. Bowyer, R.C. Newnham, F.J. Williams, D.W. Pardon	"Transducer apparatus for detecting airborne pressure pulse", US Patent 4282453 (filed 22 June 1979, granted 4 August 1981).
(127)	L.C. Knight, D.A. Cash, D. Stewart, R.A. Cottis, W.H. Bowyer, R.C. Newnham, F.J. Williams, D.W. Pardon	"Firing range", US Patent 4425500 (filed 23 July 1981, granted 10 January 1984).
(128)	L.C. Knight and R.A. Cottis	Target comprising a resilient material coated with thermoluminescent material", US Patent 4392652 (filed 16 September 1980, granted 12 July 1983)
(129)	R.A. Cottis	"Method and apparatus for monitoring corrosion", GB2407169 (application filed 6 June 2003, granted 16 November 2005).

C2 Other Research Achievement

I was awarded the T.J. Hull Award for 2005; this is one the five top awards of NACE International, awarded for contributions to NACE in the field of publications.

C3 Creative or Innovative Work

Design and construction of a computer-controlled potentiostat, together with controlling software. This has found wide use in the Centre laboratories and elsewhere.

Design of servo-hydraulic fatigue test machines, including control electronics with low cost digital waveform synthesis.

Design of electronics for Barkhausen noise measurements on fatigue specimens.

Design of hardware and software for a computer-controlled crack length measurement system.

Invention of system (subject to patent protection) for the detection of bullet trajectory in automated rifle-range system, and invention of a device for the low-cost simulation of battle-field conditions in a rifle range.

The ENAnalyse program for spectral and statistical analysis of electrochemical noise data.

C4 Supervision of Research

Post-doctoral research assistants, 6 supervised as primary or sole supervisor, 2 supervised in collaboration with colleagues.

PhD and students, 37 supervised, 26 completed, 2 failed to submit, 2 interrupted studies, 2 transferred course, 6 in progress.

MSc (research)/MPhil students, 2 supervised, both completed.

MSc students, 58 supervised, 55 completed, 3 failed to submit.

C5 Organization and Promotion of research

Major Research Contracts

Value (£k)	Period	Sponsor	Subject
28	1980-82	SERC (MTD)	The influence of marine fouling on the uptake of hydrogen by steel (PI with Dr R.A. King, CAPCIS and Dr E.D.G. Bellinger, University of Manchester).
73	1981-89	SERC (MTD) and Industry	The corrosion fatigue behaviour of steel wire rope in marine environments

Value (£k)	Period	Sponsor	Subject
96	1982-90	SERC	The influence of microstructure on the stress corrosion cracking of chain steels (PI with Dr R.P.M. Procter).
25	1983-86	SERC (MTD)	The application of hydrogen permeation measurements to the monitoring of hydrogen damage of steels.
14	1985-87	SERC and AEA Technology Ltd	CASE Studentship High temperature stress-corrosion cracking.
22	1985-87	SERC (MTD)	Instrumentation for corrosion research (CI with Dr R.C. Newman and Dr G.E. Thompson).
\$225 k	1985-88	National Bureau of Standards (USA)	The statistics of pitting corrosion (PI with Dr P.J. Laycock, Department of Mathematics).
14	1986-88	SERC	Studies in high temperature stress-corrosion cracking (CI with Dr R.P.M. Procter and Dr R.C. Newman).
72	1986-89	SERC (MTD)	Fundamentals of hydrogen embrittlement in offshore materials (PI with Dr R.C. Newman and Dr R.P.M. Procter).
52	1986-89	SERC (MTD)	Cathodic protection requirements for higher strength steels (PI with Dr R.P.M. Procter).
24	1986-89	British Gas (Engineering Research Award – studentship)	Stress-corrosion cracking in coal gasification condensates (CI with Dr R.C. Newman and Dr R.P.M. Procter).
21	1987-90	SERC and AEA Technology Ltd	CASE Studentship Oxide film properties and stress-corrosion cracking of steels in high temperature water.
12	1988-90	Alcan International	Computer simulation of alloy corrosion and activation (CI with Dr R.C. Newman).
54	1989-91	MTD Ltd and industrial sponsors	The influence of weld and heat-affected zone microstructure on the hydrogen embrittlement of micro-alloyed steels (PI with Dr R.P.M. Procter).

Value (£k)	Period	Sponsor	Subject
44	1989-91	SERC/MOD	Electromagnetic impedance spectroscopy for non-destructive evaluation (CI with Dr S.B. Lyon).
21	1989-92	SERC and National Power	Total Technology Studentship Pitting corrosion and corrosion fatigue of turbine rotor steels.
45	1990-92	SERC	Computer modelling of alloy corrosion (CI with Dr R.C. Newman).
100	1993-96	EPSRC	The Applications of Neural Networks in Corrosion Engineering (PI with Dr M. Turega, Computation)
130	1993-98	HEFCE	The Development of Computer Assisted Learning Material to support the teaching of corrosion to engineering students (TLTP Project 71)
48	1997-2000	Procter and Gamble	Corrosion Monitoring of Aerosol Cans
100	1998-2001	Ford Motor Corporation	Prediction of Corrosion Behaviour
100	1998-2001	EU	The OCEAN Thematic Network (Network Co-ordinator)
320	2000-2003	EPSRC/British Energy	Stress-Corrosion Cracking of Austenitic Stainless Steels in High Temperature Alkaline Environments (CI with Professor R.C. Newman)
90 k€	2005-2008	Electricité de France	Research Collaboration Agreement (PI with Professor A. Sherry)
33 k€	2005-2006	Electricité de France	Stress Corrosion Cracking of IN718 (PI with Dr T.J. Marrow and Professor A. Sherry)
345	2006-2008	Rolls-Royce	Construction of Imaging Autoclave (CI with Dr T.J. Marrow)
103	2006-2009	EPSRC	Enhancing the performance of pulsed current applied coatings for corrosion protection (PI with Dr S.B. Lyon and Professor J Lloyd)

Value (£k)	Period	Sponsor	Subject
145 k€	2006-2009	EDF	Modelling of Flow Assisted Corrosion of Stainless Steels in PWR Primary Water (CI with Dr N. Stevens)
168 k€	2006-2009	EDF	Effect of Strain History on the SCC of Alloy 600 in PWR Environments
750	2007-2012	EPSRC	Oxidation of zirconium alloys in high temperature water (CI with Dr M. Preuss and Dr S.B. Lyon)

Major Research Contracts in Previous Employment

Determination of the corrosion fatigue initiation properties of marine gas turbine compressor blade materials and aircraft aluminium alloys (sponsored by Admiralty Research Establishment).

Examination of the effect of contaminant diffusion into imperfectly sealed cavities on the stress corrosion cracking of aluminium components (sponsored by MOD PE).

Determination of the corrosion fatigue crack propagation properties of quenched and tempered steels and aluminium bronzes (sponsored by Admiralty Research Establishment).

An investigation into the mechanism by which a corrosive environment accelerates fatigue crack growth (sponsored by Admiralty Research Establishment).

Testing a novel concept for the construction of the lead-acid battery (commercially sponsored).

A technical survey of the existing and potential uses of manganese in batteries (sponsored by the Manganese Centre).

The assessment of a novel method of removing sulphur oxides from flue gases (commercially sponsored).

The development of manganese alloys for use as sacrificial anodes in seawater (sponsored by the Manganese Centre).

The development of manganese-containing paints for corrosion protection (sponsored by the Manganese Centre).

The assessment of the hot corrosion and oxidation resistance of two cobalt alloys (sponsored by EEC).

An investigation of the diffusion of chloride into concrete as a result of exposure to hydrogen chloride-containing atmospheres (sponsored by Building Research Establishment).

The assessment of electrode potential fluctuation monitoring as a technique for the detection of corrosion fatigue crack growth (sponsored by Admiralty Research Establishment).

Research conferences organized

Electrochemical methods in corrosion testing and research, Manchester, 4-6 Jan 1982. Around 90 participants from 12 countries. Co-sponsored by ICorrST, NACE and EFC. This meeting initiated a regular triennial series, with subsequent meetings in Toulouse (1985), Zurich (1988), Helsinki (1991), Sesimbra (1994), Trento (1997), Budapest (2000), Ysermonde (2003) and Dourdan (2006).

Electrochemical techniques in corrosion science, Manchester June 1990. A two-day national meeting organized on behalf of the Institution of Corrosion Science and Technology.

Corrosion Science Symposium, Manchester September 1991. This is four day research symposium which is held annually at Universities in the UK, sponsored by the Institute of Corrosion (formerly the Institution of Corrosion Science and Technology).

Membership of Organizing Committees of International Conferences

Member of Technical and Organizing Committees for the international conference "Electrochemical Methods in Corrosion Research", held in Toulouse, July 1985, co-sponsored by ICorrST, NACE and the Electrochemical Society.

Member of Technical and Organizing Committees for the international meeting "Environmentally-Assisted Fatigue", held in Sheffield, April 1988.

Member of Technical Committee for the third international conference on "Electrochemical Methods in Corrosion Research", held in Zurich in July 1988, sponsored by Electrochemical Society, NACE, European Federation of Corrosion and ICorrST.

Member of International Conference Committee for the meeting "Creation and Growth of Surface Cracks", held in Sheffield, 1990, sponsored by the European Group for Fracture.

Member of Technical Committee, fourth international conference "Electrochemical Methods in Corrosion Research 1991" held in Helsinki, June 1991.

Member of Organising and Technical Committees for the international conference "Advances in Corrosion and Protection", held in Manchester, June 1993.

Member of Organising and Scientific Committees, fifth international conference on "Electrochemical Methods in Corrosion Research", held in Sesimbra, Portugal, September 1994.

Member of Organising Committee, “Corrosion Fatigue”, held at Sheffield, May, 1997.

Member of Organising and Scientific Committees, sixth international conference on "Electrochemical Methods in Corrosion Research", Trento, Italy, August 1997.

Chairman of the NACE T3-U Symposium, at Corrosion 2000, Orlando, March 2000.

Member of International Scientific Committee, seventh international conference on "Electrochemical Methods in Corrosion Research", Budapest, May 2000.

Member of Local Organising Committee, EuroCorr 2000, London (September 2000).

Member of Organising Committee, Alt-C 2000, Manchester 2000.

Member of the Local Organizing Committee and Technical Committee of the International Conference on Engineering Education, Manchester, 2002.

Member of International Scientific Committee, eighth international conference on "Electrochemical Methods in Corrosion Research", Ysermonde, July 2003.

Member of the International Advisory Board of the Kurt Schwabe Corrosion Symposium, Helsinki, 2004.

Chairman, Symposium "Corrosion, Computers and the Web", Corrosion 2004, New Orleans

Chairman, Symposium "Field and Plant Applications of Electrochemical Noise", Corrosion 2005, Houston.

Member of International Scientific Committee, ninth international conference on "Electrochemical Methods in Corrosion Research", Dourdan, June 2006.

C6 Professional Advisory or Consultancy Work

In my former employment I was involved with a wide range of failure investigation and consultancy activities, ranging from the stress-corrosion cracking and pitting corrosion of food processing equipment, to corrosion of chemical plant and a major problem of legal liability for widespread failures of central heating systems.

Following my appointment I have been engaged in a number of consultancies. With a few exceptions (noted below) these have resulted from direct personal approaches.

I visited the Mamara Research Institute, Gebze, Turkey in 1982 for one month as UNIDO consultant to assist in the development of a corrosion advisory group.

Prepared survey of hydrogen embrittlement in prestressing steel and advised on failure of a marine dry dock (approached through Professor F.M. Burdekin and CAPCIS).

Consultant on sulphur corrosion of a bulk carrier, including visiting S. Africa to examine the ship in dry dock.

Investigation of the pitting corrosion of aluminium beer kegs.

Advice on the liability for the perforation and leakage of an oil transmission pipeline.

Long-term consultancy on the development of cathodic protection methods for coated reinforcement in concrete.

Hydrogen embrittlement of prestressing steel in a Calgary office building.

Examination of the hypothetical performance of martensitic stainless steels for architectural fasteners.

UNESCO consultant, the Great Man Made River Project, Libya, 2000.

Several smaller consultancies for local and national organizations.

C7 External Examining and Refereeing

Examined PhD theses for:

- University of Sheffield,
- Sheffield Hallam University,
- Cranfield University (3),
- University of Cambridge (3),
- University of Plymouth,
- University of Oxford,
- University of Cape Town (S. Africa),
- Monash University (Australia),
- Curtin University (Australia)

Examined MSc/MPhil theses for

- University of Bath,
- University of Strathclyde,
- University of Newcastle,
- University of Nairobi (Kenya),
- University of Mauritius.

Regular referee for:

- Corrosion Science,
- British Corrosion Journal (now Corrosion Engineering, Science and Technology),
- J. Electrochem. Soc.,
- Electrochimica Acta,

Journal of Physics E,
Materials Science and Technology,
Fatigue and Fatigue of Engineering Materials and Structures.

Referee for many conference proceedings.

Regular reviewer of research proposals for Flanders Institute for the Promotion of Innovation by Science and Technology (IWT-Flanders), Belgium (all expenses and fee paid).

C8 Offices in professional bodies

1978-82	Member of Institution of Corrosion Science and Technology (ICorrST), Corrosion Science Division Committee.
1980-82	Hon. Treasurer, ICorrST, Corrosion Science Division.
1989-91	Chairman, ICorrST, Corrosion Science Division. In this position I was responsible for the initiation of a regular six-monthly series of meetings on the general theme of `The Science of Corrosion'. At the time of my election there were no meetings planned for the Division.
1989-92	Member of ICorrST Council and Executive Committees.
1989-91	Chairman, U.R. Evans Award Panel of ICorrST (this is the premier British Award for corrosion scientists and engineers).
1990-	U.K. Representative, European Federation of Corrosion Working Party on Expert Systems and Databases for Corrosion.
1997-2001	Chairman of NACE T3U-8, Application of the Internet for Corrosion Control
2005-	Chair, European Federation of Corrosion Working Party 7, Education and Computer Applications
2004-	Chair, Basic Technology Working Group, ECG-COMON (a closed European technical exchange activity concerned with the application of electrochemical monitoring techniques in nuclear and other applications)
2006-	Chair, Accreditation Board, ICorrST and member of Council ICorrST

C9 Other Public Service

Member of the External Review Panel for Corrosion Monitoring at the Hanford (USA) Nuclear Waste Storage site (2001).

C10 Invited Conference Presentations and Seminars.

(1) "The Influence of Crevice Conditions on the Uptake of Hydrogen by Steel", presented to International Conference on Corrosion Chemistry Within Pits, Crevices and Cracks, NPL, London, 1984.

(2) Invited discussion leader, Corrosion Fatigue, international conference "Fundamental Questions and Critical Experiments in Fatigue", Dallas, October 1984.

(3) "Crack Chemistry and Corrosion Fatigue", invited seminar, Lehigh University, 1983.

(4) "The Corrosion Fatigue of Steels in Saline Environments : Short Cracks and Crack Initiation Aspects", presented to international conference Small Fatigue Cracks, Santa Barbara, 1986. (all expenses paid)

(5) "Electrochemical Noise Generation during Stress Corrosion Cracking", presented to 2nd International Conference on Electrochemical Methods in Corrosion Research, Toulouse, 1986.

(6) "The Role of Inclusions in Corrosion Fatigue Crack Initiation in Q1N", presented to Third International Conference on Fatigue and Fatigue Thresholds, Charlottesville (1987).

(7) "The Role of Corrosion in the Initiation and Growth of Corrosion Fatigue Cracks", presented to international conference Environment-Assisted Fatigue, Sheffield, 1987.

(8) "The Role of Crack Chemistry in Hydrogen Embrittlement", invited seminar, Battelle Pacific Northwest, Richland, USA, 1987.

(9) "The Use of Slow Strain Rate Testing for the Study of Hydrogen Effects in Steels", presented to Slow Strain Rate Technique - Value, Application and a Standard, S.C.I., London, November 1987. (all expenses paid)

(10) "A Low Cost Computer-Controlled Electrochemical Measurement System for Education and Research", presented to 3rd International Conference on Electrochemical Methods in Corrosion Research, Zurich 1988.

(11) Invited Rapporteur for international conference Environment-Induced Cracking of Metals, Kohler, Wisconsin, 1988. (In the event I was unable to attend this meeting due to indisposition at the time).

(12) "Pitting Effects in Marine Steels" invited presentation to Corrosion Pitting and its Practical Implications - Crack Initiation at Corrosion Pits, the Institute of Metals, March 1989 (all expenses paid)

(13) "Initiation Aspects of Corrosion Fatigue" invited presentation to State of the Art in Understanding Environmentally-Assisted Cracking, Engineering Integrity Society, Wolverhampton, May 1989 (all expenses paid)

(14) "Linear Electrochemical Methods", presented to NATO Advanced Study Institute, Electrochemical and Optical Techniques in Corrosion, Viana do Castelo, July 1989.

(15) "The Application of Computer Modelling Techniques in Corrosion Science and Technology", presented to Corrosion Research Symposium, UK Corrosion 89, 1989.

(16) "The Relationship between Polarization Resistance and Electrochemical Impedance Spectroscopy", invited seminar, University of Bahrain (1990) (all expenses paid).

(17) "Linear Electrochemical Methods" introductory presentation to Electrochemical Techniques in Corrosion, Manchester, June 1990.

(18) "Crack Initiation in Corrosion Fatigue", presented to Creation and Growth of Surface Cracks, Sheffield, 1990.

(19) "Effect of Cathodic Protection on the Mechanical Properties of Steels", UK Corrosion '90, Sandown Park, November 1990. (all expenses paid).

(20) "Extreme Value Statistics for the Analysis of Pitting Corrosion" invited presentation to Institute of Metals, London, 14 March 1990 (all expenses paid)

(21) "Modelling of Corrosion Processes", invited course tutor (all expenses paid), Working Party on Computer Modelling in Materials Science, International Centre for Theoretical Physics, Trieste, 5-14 June 1991.

(22) "Techniques for Analysis of Electrochemical Noise Data", presentation to "Electrochemical Noise : The Technique for the '90s", SCI Materials Preservation Group, London, 4 September 1991.

(23) "Electrochemical Methods of Corrosion Monitoring", presentation to M6 Sensors Group, Risley, 13 May 1992.

(24) "Fracture Mechanics of Stress-Corrosion Cracking", invited presentation to AEA Technology course "The Engineer's Guide to Corrosion Cracking", Warrington, May 1993. (all expenses and fee paid).

(25) "Hydrogen Embrittlement", invited presentation to *Environment-Assisted Fracture*, Institute of Corrosion, Sheffield, 1993 (all expenses paid).

(26) “Modelling of Electrochemical Noise due to Activation-Controlled Dissolution of Metals”, presented to NATO Workshop, *Modelling of Corrosion Processes, (1993)* (all expenses paid)

(27) “Environment Sensitive Fracture: an Overview”, presented to *Environment-Assisted Fracture in Industry*, ICorr meeting, Sheffield, July 1995 (all expenses paid)

(28) “OCEAN - A Collaborative Information Access Development for the Internet”, Materials Informatics, Boston, June 1999.

(29) “Electrochemical Noise Measurements for Corrosion Studies”, EMCR 97, Trento, 1997.

(30) “Techniques for the Interpretation of Electrochemical Noise”, Electrochemical Society Fall Meeting, Montreal, 1997

(31) “The Analysis of Electrochemical Noise Data”, *Research Symposium*, Corrosion 1998, Denver (expenses paid).

(32) “Measures for the Detection of Localized Corrosion with Electrochemical Noise”, Electrochemical Methods in Corrosion Research 2000, Budapest, Keynote.

(33) A Practical Evaluation of Electrochemical Noise Parameters as Indicators of Corrosion Type”, presented to Electrochemical Methods in Corrosion Research 2003, Ysermonde, Belgium, Keynote (all expenses paid).

(34) “Electrochemical Noise as a Technique for Corrosion Monitoring”, invited keynote lecture, CorCon 2005, Chennai, Tamil Nadu November 2005 (all expenses paid).

C11 Other Conference Presentations

(1) "The Corrosion Fatigue Propagation Behaviour of Steels and Aluminium Alloys", presented to Metals Society Conf. "Corrosion Fatigue", Newcastle, 1977.

(2) "Theoretical Models for Corrosion Fatigue Crack Propagation", presented to Metals Society Conf. "Corrosion Fatigue", Newcastle, 1977.

(3) "pH and Potential Measurements in an Artificial Crevice", presented to "Electrochemical Methods in Corrosion Testing and Research", ICorrST, Manchester (1982).

(4) "The Role of Inclusions in Corrosion Fatigue Initiation in a Maraging Steel", 8th Internat. Cong. on Metallic Corrosion, Mainz, 1981.

(5) "Corrosion Fatigue Initiation Processes in a Maraging Steel", presented to Metals Society Conference "Defects and Crack Initiation in Environment Sensitive Fracture", University of Newcastle upon Tyne, (1981).

(6) "The Measurement of pH and Chloride Concentration in a Simulated Crevice", presented to Symposium on Localized Crack Chemistry and Mechanics in Environment-Assisted Cracking, Philadelphia, 1983.

(7) "Polarity Reversal and Protection of Crevicing Mild Steel in Sodium Chloride Solutions", presented to International Conference on Corrosion Chemistry within Pits, Crevices and Cracks, NPL, London, 1984.

(8) "The Effect of Trace Sulphur Compounds on the Pitting of Austenitic Stainless Steels in Potable Water", presented to 9th International Congress on Metallic Corrosion, Toronto (1984).

(9) "Hydrogen Uptake by Steel Under Marine Fouling Growths", presented to 9th International Congress on Metallic Corrosion, Toronto (1984).

(10) "The Influence of Seawater Corrosion and Mechanical Damage on the Fatigue Endurance of Wire Rope", presented to Endurance Research of Wire Rope and it's Practical Applications, London, 1985.

(11) "The Influence of Seawater Corrosion on the Fatigue Strength of Steel Wire Rope", presented to Fatigue of Engineering Materials and Structures, Sheffield, 1986.

(12) "The Application of Hydrogen Permeation Measurements to the Study of Corrosion Fatigue Crack Growth in Steels", presented to 2nd International Conference on Electrochemical Methods in Corrosion Research, Toulouse, 1986.

(13) "The Influence of Crack Conditions on Hydrogen Uptake by Steel", presented to Third Int. Conf. on Fatigue and Fatigue Thresholds, Charlottesville (1987).

(14) "The Statistics of Pitting Corrosion of Austenitic Stainless Steels in Chloride Solutions", 2nd U.R. Evans Conference on Localized Corrosion, Orlando, Florida, 1987.

(15) "Chemical Conditions and Hydrogen Generation Within Crevices in Carbon-Manganese Steels", 2nd U.R. Evans Conference on Localized Corrosion, Orlando, Florida, 1987.

(16) "Effect of Tempering Temperature on Stress Corrosion Cracking of Mining Chain Steels", presented to Electrochemical Society Fall Meeting, Honolulu, October 1987.

(17) "The Effect of Marine Fouling on Hydrogen Uptake by Steel", 1st European Federation of Corrosion Symposium on Microbial Corrosion, Lisbon, 1988.

(18) "Atomistic Computer Simulation of Alloy Corrosion", to be presented to *ASTM G01.03 Symposium, "Computer Modelling for Corrosion"*, San Antonio, November 1990.

(19) "Modelling of Electrode Processes and Surface Chemistry in Carbon Dioxide-Containing Systems", to be presented to *ASTM G01.03 Symposium, "Computer Modelling for Corrosion"*, San Antonio, November 1990.

(20) "The Estimation of Corrosion Rates from AC Impedance Measurements", presented to EMCR 91, Helsinki, July 1991.

(21)) "Life Prediction in Corrosion Fatigue", presented to *Corrosion Deformation Interactions*, Fountainblau, September 1991).

(22)) "The Visualization of Corrosion Processes on an Atomic Scale", presented to *Advances in Corrosion and Protection*, Manchester (1992).

(23) "An Approach to Life Prediction in Corrosion Fatigue" presented to *Advances in Corrosion and Protection*, Manchester (1992).

(24) "The Passivation of Steel in Neutral Sodium Fluoride Solutions" presented to *Advances in Corrosion and Protection*, Manchester (1992).

(25) "The Effects of Solution Resistance on Electrochemical Noise Resistance Measurements : A Theoretical Analysis", presented *to ASTM Symposium on Electrochemical Noise*, Montreal, May 1994.

(26) "The Corrosion Information Server – Experience of the First Year", presented to Corrosion/96, Denver, 1996.

(27) "A Computer Aided Learning Package for Teaching Corrosion to Engineering Students", presented to Corrosion/96, Denver, 1996.

(28) "Monte Carlo Simulation of Electrochemical Noise Resistance Measurements", presented to Corrosion/96, Denver, 1996.

(29) "Neural Networks for Corrosion Data Reduction", presented to Corrosion/96, Denver, 1996.

(30) "The Use of Multimedia in the Teaching of Corrosion", presented to 13th International Corrosion Congress, Melbourne, November 1996.

(31) "Long-Term Monitoring of Electrochemical Noise", presented to 13th International Corrosion Congress, Melbourne, November 1996.

(32) "Crack Initiation Processes in the Corrosion Fatigue of Copper in Active Corrosion Conditions", presented to 13th International Corrosion Congress, Melbourne, November 1996.

(33) "The Influence of Coating Disbondment on the Corrosion of Coated Reinforcement - a Numerical Model", presented to Corrosion/98, San Diego, 1998.

(34) "Tuning the Internet for Corrosion", presented to Corrosion/99, San Antonio, 1999.

(35) "Neural Network Methods for the Estimation of Pitting Corrosion Behaviour", presented to Corrosion/99, San Antonio, 1999.

(36) "Higher Order Measures for EN Analysis", presented to Corrosion/99, San Antonio, 1999.

(37) "Electrochemical Noise Signature Analysis Using Power and Cross-Spectral Densities", presented to Corrosion/99, San Antonio, 1999.
(38) "Prediction of the Corrosion Rate of Steel in Seawater Using Neural Network Methods", Paper 00489, Corrosion/2000, Orlando, NACE, March 2000.
(39) "Electrochemical Noise Analysis of Carbon Steel in Sodium Chloride Solution with Sodium Nitrite as an Inhibitor", presented to Eurocorr 2000, London, 2000
(40) "Parameters for the Identification of Localized Corrosion: Theoretical Analysis", presented to the 200th Meeting of the Electrochemical Society, San Fransisco, 2001.
(41) "Measures for the Identification of Localized Corrosion from Electrochemical Noise Measurements", presented to Corrosion/2002, Denver, 2002.
(42) "Electrochemical Noise Study of Stress Corrosion Cracking of Sensitized 304H in Thiosulfate", presented to Corrosion/2003, SanDiego, 2003.
(43) "Combined Measurement of Electrochemical Noise and Electrochemical Impedance", presented to Corrosion/2003, SanDiego, 2003
(44) "Laboratory Testing and Computer Modeling of the Performance of Sacrificial Anodes for use in Reinforced Concrete Structures", presented to Corrosion/2003, SanDiego, 2003
(45) "The Simultaneous Measurement of Electrochemical Impedance and Electrochemical Noise", R.A. Cottis, M. Kumaraguru, M. Marti, L. Daněk and V. Matoušek, presented to EIS 2004, Cocoa Beach, May 2004.
(46) "The use of electrochemical noise to detect initiation of stress corrosion cracking", A.A.M. Gebril and R.A. Cottis, present to Corrosion/2005, Houston 2005.
(47) "Modeling of Image Formation and Image Enhancement for Scanning Electrochemical Methods", R.A. Cottis and S.B. Lyon, presented to Corrosion/2005, Houston 2005.
(48) "Error Sources and Image Enhancement in Scanning Electrode and Related Techniques", R.A. Cottis and S.B. Lyon, presented to Eurocorr 2005, Lisbon, September 2005.
(49) "Mentor-C – a Resource for Corrosion Education", W. Bogaerts, R.A. Cottis, S.B. Lyon, P. McIntyre, M. Piens, G. Pimenta, P. Poh and Thuy Vuthi, presented to Eurocorr 2005, Lisbon, September 2005.

C12 Major academic visits and collaborations

Collaborative research with the University of Santiago de Compostela, Spain.

Collaborative research with Instituto Eduardo Torroja, Madrid, supported by British Council.

Collaborative research with the University of Bahrain (1990). (expenses paid).

Collaborative research with the University of Rome, Tor Vegata.

Collaboration on Corrosion Teaching with ITESM, Monterrey, Mexico (2000), supported by British Council.

Visiting professor, University of Burgundy, Dijon, 2002-.

Collaborative research with the Universities of Milan (2002), Cadiz (2003) and Brno (2004) supported by the EU through Marie-Curie Training Fellowships.

Collaborative research with the University of Nairobi (Kenya), supported by a Commonwealth Scholarship.

C13 Statement on Research

My research has contributed to the international development of the subject in a number of areas. As is normal in university research, the day-to-day research has been undertaken primarily by post-doctoral research assistants, research students and dissertation students working with me (and identified as authors of the relevant papers), while the developments in interpretation, analysis and modelling have been a partnership to which I have generally been the major contributor, except for the collaboration with colleagues detailed below.

In summary, the main area of early research has been in the mechanistic aspects of corrosion fatigue, both in respect of crack initiation, which is significant primarily for smaller components and where my work has demonstrated the role of corrosion in assisting the initiation process, and crack growth, where my work has shown that larger cracks, such as those found in offshore structures, are relatively unaffected by corrosion and hydrogen entering the steel is a more important factor. In collaborative work I have been responsible for the clarification of the interpretation of the results of existing electrochemical techniques, and I have contributed to improvements in the statistical interpretation of pitting corrosion, both of which are of considerable industrial significance. On a more fundamental note, I have also developed very efficient algorithms for the modelling of alloy corrosion. Most recently, I have been one of the leaders in the development of a fundamental understanding of the theoretical basis of electrochemical noise measurements, and in the better understanding of the capabilities and limitations of the use of artificial neural network methods for modelling corrosion processes.

The most significant developments in environmentally-assisted fracture have probably been made in the field of crack initiation in corrosion fatigue. These arose out of a recognition that the application of fracture mechanics to corrosion fatigue had diverted attention from the early stages of crack initiation and growth. By studying the growth of very short cracks (generally less than 1 mm) I have been able to develop very clear qualitative models of crack growth processes and the role of corrosion in this regime (see references 83, 84, 18, 21, 70, 22, 24, 27, 28, 104, 13). Additional mechanistic studies examined model systems (notably copper in $CuSO_4/H_2SO_4$) to elucidate the role of corrosion (77).

I also commenced work on the chemical conditions within corrosion fatigue cracks soon after taking up my position. The results of this work, which remains the experimental standard by which theoretical models are judged, were able to confirm the theoretical predictions developed at about the same time by Turnbull and others at NPL. This experimental work provided two significant advances in the state of knowledge of the subject. Firstly, both as a result of over-simplified analogies with the crevice corrosion of stainless steels, and a number of apparently sound experiments, it was believed at the time my work commenced that the solution in a fatigue crack for a carbon steel in seawater was quite acid (about pH 2). My work, in agreement with the theoretical predictions of Turnbull, demonstrated that in fact the solution was very slightly alkaline, and the earlier experimental results were in error because of oxidation of the solution prior to the measurement of the pH (14, 15, 90, 91, 92, 68). A second observation of my experimental work, which was not predicted by early theoretical models, was that the hydrogen overpotential could be *increased* by anodic polarization, contrary to the expectations and assumptions of most workers in this field, who had frequently used anodic polarization as a test for the behaviour of a sample in conditions for which hydrogen embrittlement was not possible. This observation has since been confirmed by numerical models (116).

At the same time as the initial work on the chemical conditions within the corrosion fatigue crack, I started to use the electrochemical hydrogen permeation technique to measure the rate of hydrogen entry into the steel, initially to study the influence of marine fouling growths on hydrogen entry (94, 102, 64). This technique was then combined with the techniques for the study of conditions within cracks to study the influence of conditions within a simulated crack on the rate of hydrogen entry. This work demonstrated very clearly that hydrogen embrittlement could indeed occur under conditions where it had previously been assumed by most workers to be impossible (16, 86, 20, 68). This lead further to the use of the hydrogen permeation technique to study the details of hydrogen embrittlement processes in somewhat more detail, with a view to optimising welding procedures for higher strength steels for use in marine environments (30, 32). This also relates to earlier work in collaboration with Dr R.P.M. Procter on the effect of tempering temperature on the hydrogen embrittlement susceptibility of chain steels, where the link between hydrogen entry, heat treatment conditions and susceptibility to hydrogen embrittlement were clearly demonstrated (65).

Also in the field of corrosion fatigue I have been heavily involved with studies of the effects of corrosion on the fatigue of steel wire rope (17, 19). This largely phenomenological study was supported through a programme funded by SERC/MTD in collaboration with a number of offshore operators.

In addition to the above research areas, which have primarily been conducted by myself in association with research students or research assistants, I have also been engaged in a wider range of research projects in collaboration with my colleagues in the `Environmental Cracking Group', Dr R.P.M. Procter and Dr R.C. Newman. These include a range of studies of mechanistic aspects of stress-corrosion cracking and hydrogen embrittlement, together with the use of Monte-Carlo computer modelling to help understand the corrosion of alloys (97, 100, 25). The latter work provided new insights in the processes underlying the corrosion of alloys, and has given a very simple explanation of a range of phenomena, such as the sharp compositional thresholds for transitions in dealloying and passivation behaviour, which had previously been difficult to interpret. My contribution to this work has been largely concerned with the computing aspects of the study, and in particular the development of efficient algorithms for the modelling, where I have been able to reduce the 3-dimensional problem from order N^3 to approximately N^2.

In the case of the development of the theory of electrochemical noise, I published one of the first descriptions of the currently-accepted analysis of the electrochemical noise resistance technique (31, 107, 33). Others have since published more complex analyses, but these have not significantly extended the basic theoretical treatment. The theories were subsequently tested with a simple Monte-Carlo model of a noise generation process (37). I have been invited to a number of international conferences to present this work, and have written a commissioned book that is the standard reference for the measurement and interpretation of electrochemical noise in corrosion (4). More recently, I have produced a major invited review of the theoretical aspects of electrochemical noise analysis (124), which is widely cited (45 citations as of the end of 2006). The theoretical analysis that has been developed in this work has recently led to the award of a patent for a novel measurement method that combines electrochemical impedance and electrochemical noise methods (129). With the assistance of two Marie-Curie students, this has been realised as a practical instrument, based on digital signal processor technology (presented to EIS 2004).

A range of experimental projects have added to the understanding of the electrochemical noise technique, including very long-term measurements that provide an estimate of the electrochemical impedance at frequencies down to 10^{-6} Hz (49). Working with Dr S. Turgoose (who provided support on the corrosion inhibition aspects) I have also studied electrochemical noise generation during inhibitor depletion (112,113,78,48). This has been particularly fruitful; as well as clarifying the way in which breakdown of inhibition occurs, it provided a high quality data set that has provided considerable insight into electrochemical noise theory. In particular it provided support for an analysis based on shot noise theory (47,54) that is gradually gaining support as a simple, yet theoretically sound, indicator of the extent of localized corrosion.

My work on electrochemical techniques was initially concerned with the development of methods appropriate for the study of environmentally-induced fracture, such as the measurement of chemical conditions in cracks and crevices (90, 91), and the study of electrochemical noise generated during stress-corrosion crack growth (85, 67, 88, 93, 96, 98, 122). In the latter field I was responsible for the first measurements of electrochemical noise associated with environmentally-induced fracture. Recently, in collaboration with Dr S. Turgoose, computer models have been used to examine the fundamental aspects of existing electrochemical techniques. These have helped to clarify the relationship between apparently different techniques, and to demonstrate some of the fundamental limitations of the techniques (23, 26, 103, 29). This has been an equal collaboration; I initiated the studies of the relationship between transient and impedance techniques and undertook the transformations from the time to the frequency domain, Dr Turgoose developed the detailed mass transport model, and has further developed the model in his field of interest in CO_2 corrosion. I also used a similar approach to analyse the expected performance of sacrificial anodes embedded in concrete (51). As well as clarifying the expected performance of such anodes, the work identified some potential problems associated with the influence of the compositional gradients induced by the application of current to the concrete. More recently work has been commenced, using finite element methods, on the re-evaluation of the theoretical basis of cathodic protection, where it is becoming clear that current ideas of the mechanism of cathodic protection are over simplistic. In parallel with this work, I have been collaborating with Dr Roland Oltra at the University of Burgundy, Dijon, on the modelling of crevice chemistry, using the same finite element tools (53).

In practical electrochemistry I have been responsible for the development of a range of low-cost electrochemical instrumentation for use in the research laboratories (95). This work is currently being extended to take advantage of low-cost commercial data acquisition systems (5).

In a project on the effect of nitrogen introduced during welding of duplex stainless steels (105,73,74,75,108,35,39) new welding procedures were developed, and several aspects of the pitting corrosion process clarified. In particular, the role of surface oxidation was identified.

My work on the statistical aspects of pitting corrosion arose out of my teaching activities in corrosion testing, which introduced me to the application of extreme-value statistics to the extrapolation of expected pit depths, and initiated a project that examined the statistics of pitting corrosion (87). This work also provided some of the early evidence that traces of reduced sulphur species in solution can have a dramatic effect on the pitting corrosion of stainless steels (63). In collaboration with Dr P.J. Laycock of the Department of Mathematics this has been extended to a practical and theoretical study of the long term statistics of pitting corrosion, with a particular eye to the disposal of nuclear waste (99, 69, 101). This work has demonstrated that most prior workers have used inappropriate models for the extrapolation of pitting data, with the result that extrapolated maximum pit depths have been considerably over-estimated. This has been a reasonably equal partnership; while the development of the theoretical and algorithmic aspects of the problem has clearly been the responsibility of Dr Laycock and his colleagues, I was responsible for the initiation of the project, and for the production of very large quantities of experimental data on which to test the mathematical models. The collaboration with Dr Laycock also resulted in the first application of bispectral methods to the analysis of electrochemical noise data (109, 44).

In collaboration with Dr M. Turega, Department of Computation, I have been engaged in the application of neural network techniques to corrosion studies. The variability and poor quality of corrosion data has lead to the development of new techniques. These allow, for example, the description of predicted corrosion rate in terms of three parameters; the mean rate, the expected variance (the variance being derived from the training data, and varying over the problem space), and the 'confidence' (representing the estimated reliability of the prediction, based, among other things, on the 'closeness' of training data to the prediction point) (34, 38). Other work has been concerned with the reliability of input parameter reduction methods, notably the use of the pitting resistance equivalent to represent compositional effects in the pitting of stainless steels (38, 110, 43, 46), and the modelling of atmospheric corrosion data (111). Current developments are concerned with the wider application of the techniques that have been developed, together with studies of the ways in which human expertise can be merged with neural network techniques. More recently, neural network techniques have been used to model the electrochemistry of iron in solutions of varying chloride content and pH (52).

I have been engaged in a number of projects involving aqueous corrosion at elevated temperature and pressure, including studies of stress corrosion cracking in environments associated with the PWR (49). Recently this has lead to the long-term collaboration agreement with EDF that I am leading. In this field I have been active in the development of research within the Materials performance Centre.

I am also becoming increasingly involved in the application of IT to corrosion technology. One of the most significant projects has been the OCEAN (Open Corrosion Expertise Access Network) Thematic Network, of which I was Network Co-ordinator. This has developed a metadata description for corrosion information, based on the Dublin Core (42). This format has recently been used to provide a standard method of reporting electrochemical noise data (81).

D - Administration

Departmental

Editor of departmental Research in Progress Brochure from 1980 to 1994, together with other departmental literature (MSc prospectus, advertising posters, promotional leaflets etc.). Word processing and desk-top publishing methods were introduced to reduce production costs and increase accuracy. Illustrations were also introduced into the brochure to improve the attractiveness, and the brochure has been used by several groups (both in Manchester and elsewhere) as a model.

Developed and managed an ERASMUS ICP with the University of Burgundy, Dijon, Instituto Superior Tecnico, Lisbon, and the Danish Technical University, Lyngby. The ICP ran from 1991 to 1997, when it was incorporated into the UMIST Socrates programme.

Preparation of timetables, including the development of a computer program for the optimization of timetables for the option modules scheme (1990-1994).

Specification, introduction and support of word-processing and computer systems in the department. These were initially based on Apricot PCs and Vuwriter. They were upgraded in 1990 to Word Perfect on IBM PC compatible computers, and in 1996 to Microsoft Word. While we have used the training courses at the Staff Teaching Workshop, the provision of day-to-day support during the introductory and transitional periods has taken a lot of my time (1985-2001), especially with the introduction of the computer network, which I managed within the department.

Maintenance of Research in Progress mailing list. This has been transformed from a card-index-based list of about two hundred entries, to a computer-based list which has reached 1600 entries, with regular annual updating to target the mailing (1980-).

Departmental MSc course and research advertising organiser (1984-1994).

Departmental library representative (1982-2004) and organiser of departmental library (prior to incorporation into Joule library) and preparation of MSc course reading list (1982-).

Departmental computer representative (1979-2000)
Careers service and employment liaison (1984-).

Chairman, Departmental Academic Board (1988-2004).

UMIST/University of Manchester

Member, Graduate School Council (1998-2001)
Member, Board of Graduate Studies (1999-2001)
Chairman, Working Party to enhance Web-based Careers information for MSc students (1999-2000).
Chairman, Distance Learning Interest Group (1999-2004).
Invited Member, UMIST Academic Board (1988-2004).
Member, Library Users Subcommittee (1988-2001), Chair (2001).
Departmental representative on Group 9 Library Subject Panel for all of its existence (1988-90).
Member UMIST Library Committee (1996-99) and Library Services Committee (1999-2001).
Member Teaching and Learning Committee (1998-2004).
Member, UMIST Continuing Professional Development Committee (1996-1999).
Member, UMIST CAL Working Party/Teaching Technology Sub-Committee (1994-1999).
Member of Periodic Programme Review Panels (Textiles, 2003, and Chemical Engineering, 2004).

Member, UMIST (computer) Users Subcommittee (1979-99).
Member UMIST Academic Information Systems Committee (1996-99).

Departmental representative on Chemical Engineering Departmental Academic Board (1982-1993).

Member, AFR Sub-Group 3, Project Unity
Member Faculty PGT Panel (2005-).

D4 Statement on Administration

I have been heavily involved in administrative activities within the Corrosion and Protection Centre and the University. In particular I was Chairman of the Departmental Academic Board from 1988-2004, and I have also chaired a number of University Committees.

I am a regular referee for all major corrosion and many related journals, and for several conference proceedings

I have been active in the Institute of Corrosion, NACE, and the European Federation of Corrosion, where I am Chairman of Working Party 7, Education and Computer Applications.

On a more practical note I have lead (my colleagues might say forced) the introduction of IT to the Corrosion and Protection Centre since “pre-IBM PC” times.

ATTACHMENT B

Contentions Adopted By **Robert A. Cottis** In Accordance With Affidavit
NEV-SAFETY-73
NEV-SAFETY-75
NEV-SAFETY-76
NEV-SAFETY-80
NEV-SAFETY-81
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NEV-SAFETY-107
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NEV-SAFETY-109
NEV-SAFETY-110
NEV-SAFETY-124
NEV-SAFETY-125
NEV-SAFETY-126
NEV-SAFETY-127
NEV-SAFETY-128
NEV-SAFETY-129
NEV-SAFETY-142

Attachment 19

Affidavit of Richard E. Chandler

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of U.S. DEPARTMENT OF ENERGY License Application to Construct a Geologic Repository at Yucca Mountain	))))))))	Docket No. 63-001

AFFIDAVIT OF RICHARD E. CHANDLER

I, Richard E. Chandler, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Richard E. Chandler, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

~~Further, the affiant sayeth not.~~

RCL AFS

RCLC

Richard E. Chandler

The above-named affiant personally appeared before me this 17th day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: WITH LIFE

ANN FRANCES STANYER
NOTARY PUBLIC

ANN FRANCES STANYER
ATRIUM COURT
15 JOCKEY'S FIELDS
HOLBORN, LONDON WC1R 4QR
NOTARY PUBLIC & SOLICITOR

ANN FRANCES STANYER NOTARY PUBLIC

ATTACHMENT A

CURRICULUM VITAE

RICHARD E. CHANDLER

CURRICULUM VITAE – RICHARD CHANDLER

Full Name:	Richard Eric Chandler	**Date of Birth**:	16th March 1969
Nationality:	British	**Marital status**:	Single

Employment history

2004-date	Senior Lecturer in Statistics, Department of Statistical Science, University College London.
1997-2004	Lecturer in Statistics, Department of Statistical Science, University College London.
1997	Visiting Scientist, CSIRO Land and Water, Perth, Western Australia (July-August).
1994-1997	Research Associate, jointly at Department of Statistical Science, University College London; and at Department of Civil Engineering, Imperial College London.
1993	Visiting Lecturer, Optometry Department, UMIST (October-December).
1990-1993	Dental Health Unit, University of Manchester: Statistical and computing support for a unit involved in clinical trials.
1990-1993	Various Health Authorities in the Manchester area: statistical and computing support.
1987-1990	British Telecom, Liverpool District: Bursary Student.

Education

1990-1993	UMIST: PhD (Mathematics), subject *The Application of Spectral Methods to the Analysis of Point Process Data*.
1987-1990	UMIST: B.Sc. in Mathematics, Statistics & Operational Research (1st Class Hon.).
1980-1987	Wirral Grammar School for Boys, Cross Lane, Bebington, Merseyside: 'A' Levels: Mathematics, Further Mathematics, Geology, Music, General Studies

Main administrative responsibilities in current employment

2004-	Director of Studies and Chair of Departmental Teaching Committee
2000-2004	Tutor to Economics and Statistics degree programme
1999-	First aid qualified person.

Professional service

2007	Member of scientific organising committee, 10th International Meeting on Statistical Climatology, Beijing
2006-	Secretary, Royal Statistical Society Environmental Statistics Section (on committee since 2003)
2005-	Associate Editor, JRSS Series C Applied Statistics.
2004-	Lecturer on several training courses *Statistics for Environmental Evaluation,* funded by NERC and organised by the Department of Statistics at University of Glasgow
2003-	Member of DEFRA Peer Review Panel
2003-2007	Committee member, Royal Statistical Society General Applications Section.
2003-2005	Member of EPSRC Peer Review College.
2002	Delivered a three-day course *Advanced analytical methods for climate research* at the Institute of Atmospheric Physics, Beijing. Lecture notes available at http://www.homepages.ucl.ac.uk/~ucakarc/work/glmnotes/.

Refereeing: for a wide range of journals in the environmental and physical sciences as well as in statistics

PhD examining: acted as internal examiner for six University of London PhD candidates, and as external for candidates in Glasgow and Beijing.

Membership of professional bodies

Fellow of the Royal Statistical Society
Member of the Bernoulli Society
Honorary member of the Institute of Atmospheric Physics, Beijing

Consultancy work

2007-	Advice on transfer function modelling with application to groundwater systems, for British Geological Survey.
2007-8	Advice on assembling and analysing national archive of surface water temperature data, for UK Environment Agency (with consortium led by S. des Clers, ENSIS, UCL)
2006-	Development of commercial version of GLIMCLIM software package (see publications), with Halcrow plc.
2004-	Provision of advice to State of Nevada on rainfall modelling and uncertainty analysis in safety assessment of Yucca Mountain nuclear waste storage facility.

2000 Provision of investigation into rainfall data requirement and supporting raingauge network design (with H.S. Wheater, V.S. Isham, C. Onof and W.S. Atkins Consultants Ltd.), for UK Meteorological Office.

1999-2000 *A rainfall disaggregation scheme for operational use* (with N.G. Mackay, C. Onof and H.S. Wheater), for UK Meterological Office.

1998 *Modelling of heating degree days for quantifying insurance risks* (for Tempest Re, Bermuda).

1997-2004 Training lectures and workshops for UK insurance industry.

1996-1998 Report to MacDowells plc on the role of rainfall in flooding in the Gort region of Western Ireland (with H.S. Wheater).

Research interests

Time series, space-time modelling and associated inference techniques, hydrology, climatology and other environmental applications.

Research funding

10/2003-9/2006 DEFRA project FD2113 *Spatial-temporal rainfall modelling with climate change scenarios* (joint with H.S. Wheater, V.S. Isham and C. Onof), value £154K.

10/2002 NERC Ph.D studentship *A Bayesian probability framework for assessing climate change simulations.*

5/2002-4/2005 DEFRA project FD2105 *Improved methods for national spatial-temporal rainfall and evaporation modelling for BSM* (joint with H.S. Wheater, V.S. Isham and C. Onof).

9/1999-8/2001 Award from TSUNAMI *Investigation of the risk from climate variability and change over Northern Europe* (joint with H.S. Wheater and V.S. Isham), value £55K.

1/1998-12/1999 Award from MAFF *Generation of spatially consistent rainfall data* (joint with H.S. Wheater, V.S. Isham and C. Onof), value £149K.

Research students

2008- Olalekan Obisesan (*Multivariate time series modelling with application to water pollution and public health*)

2008- Simon Harden (*Inference with composite likelihoods*)

2007- Chiara Ambrosino (*Water shortage and drought in South Africa*; co-supervised with the Geography Department at UCL)

2007- Mohammud Shamsudduha (*Groundwater dynamics, water resources and arsenic mobilisation in Bangladesh: a national-scale study*; co-supervised with the Geography Department at UCL)

2007- Joao Jesus (*Inference without the likelihood function*)
2003-2007 Nadja Leith (*Downscaling climate model outputs for hydrological applications*)
2000-2003 Steven Bate (*Generalized linear models for large dependent data sets*)

Research in progress

Current areas of research investigation include:

- An investigation into the drivers of the current drought in Western Australia (with collaborators at CSIRO), with a view to informing water resource management / adaptation strategies.
- Quantifying and handling uncertainty in climate model projections for the 21^{st} century. This work involves the development of hierarchical models for multivariate time series, and poses some interesting theoretical and computational challenges.
- Work on the comparison of estimating equations (e.g. when one estimating equation is more efficient than another under more restrictive assumptions that are difficult to verify in practice).
- Work (with PhD student Joao Jesus) on inference for stochastic processes when a likelihood function is unavailable, either because of intractability or because the full distributional structure is deliberately left unspecified.
- Work (with PhD students Chiara Ambrosino and Mohammud Shamsudduha) on quantifying spatial structure of rainfall fields in tropical and subtropical areas, with particular application to the estimation of, and implications of climate change for, groundwater recharge.

In addition, I serve in advisory capacity to the EU Framework 6 programme *EUROLIMPACS* (see http://www.eurolimpacs.ucl.ac.uk/) and am currently involved in a bid to EPSRC to look into *Drought risk under climate change – adaptation and resilience of UK infrastructure* (jointly with the Imperial College and British Geological Survey.).

Publications

Refereed journal papers:

Chandler, R.E., Isham, V.S., Bellone, E., Yang, C. and Northrop, P.J. (2007). Space-time modelling of rainfall for continuous simulation. Chapter 5 in Finkenstadt, B., Held, L., Isham, V.S. (ed.) *Statistical methods for spatial-temporal systems*. Boca Raton: CRC Press.

Chandler, R.E. and Bate, S. (2007). Inference for clustered data using the independence log-likelihood. *Biometrika* **94**: 167-183.

Yan, Z., Bate, S., Chandler, R.E., Isham, V. and Wheater, H. (2006): Changes in extreme wind speeds in NW Europe simulated by generalized linear models. *Theoretical and Applied Climatology* **83**: 121-137.

Yang, C., Chandler, R.E., Isham, V.S. and Wheater, H.S. (2006): Quality control for daily observational rainfall series in the UK. *Water and Environment Journal* **20**: 185-193.

Wheater, H.S., Chandler, R.E., Onof, C.J., Isham, V.S., Bellone, E., Yang, C., Lekkas, D., Lourmas, G. and Segond, M-L. (2005) Spatial-temporal rainfall modelling for flood risk estimation. *Stochastic Environmental Research and Risk Assessment* **19**: 403-416.

Yang, C., Chandler, R.E., Isham, V. and Wheater, H.S. (2005). Spatial-temporal rainfall simulation using Generalized Linear Models. *Water Resources Research* **41**, doi:10.1029/2004WR003739.

Chandler, R.E. (2005). On the use of generalized linear models for interpreting climate variability. *Environmetrics* **16(7)**: 699-715.

Yang, C., Chandler, R.E., Isham, V.S., Annoni, C. and Wheater, H.S. (2005). Simulation and downscaling models for potential evaporation. *Journal of Hydrology* **302**: 239-254.

Chandler, R.E. and Wheater, H.S. (2002). Analysis of rainfall variability using generalized linear models: a case study from the west of Ireland. *Water Resources Research* **38(10)**, 1192, doi:10.1029/2001WR000906.

Chandler, R.E. (2002). *GLIMCLIM: Generalised linear modelling for daily climate time series (software and user guide)*. Research Report No. 227, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs02.html#227)

Yan, Z., Bate, S., Chandler, R.E., Isham, V. and Wheater, H. (2002). An analysis of daily maximum windspeed in northwestern Europe using generalized linear models. *J. Climate* **15(15)**: 2073-2088.

Chandler, R.E., Wheater, H.S., Isham, V.S., Onof, C., Bate, S., Northrop, P.J., Cox, D.R., and Koutsoyiannis, D. (2002). Generation of spatially consistent rainfall data. In *BHS Occasional Paper No. 13 Continuous river flow simulation: methods, applications and uncertainties* (IG. Littlewood, ed.), pp.59-65. British Hydrological Society.

Mackay, N.G., Chandler, R.E., Onof, C. and Wheater, H.S. (2001). Disaggregation of spatial rainfall fields for hydrological modelling. *Hydrological and Earth System Sciences* **5**: 165-173.

Wheater, H.S., Isham, V.S., Cox, D.R., Chandler, R.E., Kakou, A., Northrop, P.J., Oh, L., Onof, C. & Rodriguez-Iturbe, I. (2000). Spatial-temporal rainfall fields: modelling and statistical aspects. *Hydrology and Earth System Sciences* **4**: 581-601.

Onof, C., Chandler, R.E., Kakou, A., Northrop, P., Wheater, H.S. and Isham, V. (2000). Rainfall modelling using Poisson cluster processes: a review of developments. *Stochastic Environmental Research and Risk Assessment* **14**: 384-411.

Chandler, R.E., Mackay, N.G., Wheater, H.S. & Onof, C. (2000). Bayesian image analysis and the disaggregation of rainfall. *J. Atmos. and Oceanic Technol*. **17**: 641-650.

Saunders, M.A., Chandler, R.E., Merchant, C.J. & Roberts, F.P. (2000). Atlantic hurricanes and NW Pacific typhoons: ENSO spatial impacts on occurrence and landfall. *Geophysical Research Letters* **27(8)**: 1147-1150.

Wheater, H.S., Isham, V.S., Onof, C., Chandler, R.E., Northrop, P.J., Guiblin, P., Bate, S.M., Cox, D.R. and Koutsoyiannis, D. (2000). *Generation of spatially consistent rainfall data*. Research Report No. 204, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs98.html#204).

Isham, V., Northrop, P., Chandler, R.E., Onof, C. and Wheater, H. (1999). Spatial-temporal stochastic modelling for hydrological design. In *Hydrological extremes: understanding, predicting, mitigating* (eds L. Gottschalk, J.C. Olivry, D. Reed and D. Rosbjerg).

Wheater, H.S, Jolley, T.J., Onof, C., Mackay, N.G. and Chandler, R.E. (1999). Analysis of aggregation and disaggregation effects for grid-based hydrological models and the development of improved precipitation disaggregation procedures for GCMS. *Hydrology and Earth System Sciences* **3**: 95-108.

Onof, C., Mackay, N., Chandler, R.E. & Wheater, H.S. (1998). A rainfall disaggregation scheme for forecasting. In *Hydrology in a Changing Environment* (eds. H.S. Wheater and C. Kirby), pp.107-116. Wiley, Chichester.

Armitage, P. & Colton, T. (eds) (1998) *Encyclopedia of Biostatistics* (Wiley). Articles on Model checking and Orthogonality.

Chandler, R.E., Isham, V.S. Northrop, P.J. (1997). Spatial-temporal rainfall processes: stochastic models and data analysis. In *Statistical Computing and Graphics Newsletter*, vol. 8 No. 2/3.

Chandler, R.E., Mackay, N., & Onof, C. (1997). Application of Bayesian image analysis techniques to the problem of rainfall disaggregation. In *Proceedings in the art and science of Bayesian image analysis* (K.V. Mardia, C.A. Gill and R.G. Aykroyd), pp.132-142. Leeds University Press.

Chandler, R.E., Mackay, N., Wheater, H.S. & Onof, C. (1997). *Bayesian image analysis and the disaggregation of rainfall*. Research Report No. 184, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs97.html#184)

Wheater, H.S., Isham, V.S., Cox, D.R., Chandler, R.E., Kakou, A., Northrop, P.J., Oh, L., Onof, C. & Rodriguez-Iturbe, I. (1997). *Spatial-temporal rainfall fields: modelling and statistical aspects*. Research Report No. 176, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs97.html#176)

Chandler, R.E. (1997) A spectral method for estimating parameters in rainfall models. *Bernoulli* **3(3)**: 301-322.

Chandler, R.E. (1996) A note on analytical solutions to the Whittle likelihood equation. Research Report No. 173, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs96.html#173)

Subba Rao, T. & Chandler, R.E. (1996) A frequency domain approach for estimating parameters in point process models. pp.392-405, *Athens Conference on Applied Probability and Time Series, Vol. II: Time Series Analysis (in memory of E.J. Hannan)*. P.M. Robinson & M. Rosenblatt, eds. Lecture notes in Statistics 115, Springer-Verlag, New York.

Chandler, R.E. (1996) *The spectral analysis of spatial-temporal rainfall models*. Research Report No. 158, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs96.html#158)

Chandler, R., Isham, V., Kakou, A. & Northrop, P. (1995) Spatial-temporal rainfall processes: stochastic models and data analysis. *Proceedings, 5th International Conference on Statistical Climatology, Galway*. Also available as Research Report No. 148, Department of Statistical Science, University College London (http://www.ucl.ac.uk/Stats/research/abs95.html#148)

Clerehugh V., Lennon M.A., Worthington H.V. & Chandler R.E. (1995): Site analysis of progression of loss of attachment in a 5 year longitudinal study of adolescents. *Journal of Clinical Periodontology* **22**: 15-21.

Book reviews

H. von Storch and F.W. Zwiers (1999): *Statistical Analysis in Climate Research*. Reviewed in The Statistician **51(4)**: 587-8.

J. Møller and R.P. Waagepetersen (2004): *Statistical Inference and Simulation for Spatial Point Processes*. ISI Short Book Reviews, to appear (August 2004).

A.C. Davison (2003): *Statistical Models*. ISI Short Book Reviews, to appear.

W.N. Venables and B.D. Ripley (2002): *Modern Applied Statistics with S (4th edition)*. Reviewed in J. Time Series Anal., **26**.

In preparation

R.E. Chandler and E.M. Scott (eds): *Statistical Methods for Trend Detection and Analysis in the Environmental Sciences*. Wiley, Chichester.

ATTACHMENT B

Contentions Adopted By **Richard E. Chandler** In Accordance With Affidavit
NEV-SAFETY-14
NEV-SAFETY-15
NEV-SAFETY-16
NEV-SAFETY-17
NEV-SAFETY-18
NEV-SAFETY-24
NEV-SAFETY-28
NEV-SAFETY-29
NEV-SAFETY-30
NEV-SAFETY-34
NEV-SAFETY-35
NEV-SAFETY-37
NEV-SAFETY-38
NEV-SAFETY-39
NEV-SAFETY-40

Attachment 20

Affidavit of Steven A. Frishman

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF STEVEN A. FRISHMAN

I, Steven A. Frishman, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Steven A. Frishman, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Steven A Frishman

Steven A. Frishman

The above-named affiant personally appeared before me this 12 day of December, 2008, and executed this affidavit.

E. SAUNDERS
Notary Public State of Nevada
No. 02-76712-1
My appt. exp. Aug. 14, 2010

E Saunders

Notary Public

My Commission expires: 08.14.2010

ATTACHMENT A

CURRICULUM VITAE

STEVEN A. FRISHMAN

Steven A. Frishman
3926 Bushnell Drive, #71
Las Vegas, NV 89103
Phone: 702/248-1127

Date of Birth: September 15, 1944
Place of Birth: Washington, D.C.
Citizenship: U.S.

ACADEMIC BACKGROUND:

B.A. Geology, 1966 - Clark University, Worcester, Mass.
M.A. Geology, 1969 - The University of Texas at Austin
Certificate, National Oil Spill Control School, 1977 - Corpus Christi, Texas
Certificate, Nuclear Quality Assurance Specialist, 1982
Certificate, Nuclear Quality Assurance Auditor, 1982

PROFESSIONAL EXPERIENCE:

Technical Consultant, Egan, Fitzpatrick & Malsch, PLLC (December 2008 – present).

Technical-Policy Coordinator, Nevada Agency for Nuclear Projects, Nuclear Waste Project Office (September 1987 – November 2008).

Director, Nuclear Waste Programs Office, Texas Department of Public Safety, Division of Emergency Management (September 1984 - August 1987).

Director, Nuclear Waste Programs Office, State of Texas, Office of the Governor, General Counsel Division (September 1983 - August 1984).

Manager, Office of High-Level Nuclear Waste Affairs, Texas Energy and Natural Resources Advisory Council (February 1983 - August 1983).

Research Associate, Bureau of Economic Geology, The University of Texas at Austin (February 1982 – January 1983).

Consultant, National Advisory Committee on Oceans and Atmosphere, Independent Area Task Force for Fisheries (May 1981 - May 1982).

Consultant, Coastal Resources Management (owner), Port Aransas, Texas (January 1978 - January 1982).

Owner-Publisher, South Jetty Newspaper (weekly), Port Aransas, Texas (1971 - 1980).

Technical Advisor, U.S. Environmental Protection Agency, Washington, D.C. (August 1979 - July 1980).

Technical Consultant, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington (May 1979 - April 1980).

Consultant, Texas General Land Office, Austin, Texas (1978).

COMMITTEES:

Federal -

Shark Advisory Panel, U.S. Department of Commerce, Gulf of Mexico Fishery Management Council, Chairman (1981 - 1989), Vice Chairman (1977 - 1980).

Eastland Resolution Ad Hoc Committee, U.S. Department of Commerce, Gulf States Marine Fisheries Commission, Member, Hearing Committee (1975 - 1976).

State -

Texas Coastal and Marine Council, State of Texas, Appointee (1978 - 1985).

Standing Advisory Committee on Nuclear Energy, Texas Energy and Natural Resources Advisory Council (1980 - 1982).

Coastal Bend Council of Governments, Environmental Quality Committee, Corpus Christi, Texas (1973 - 1982).

Citizen Advisory Committee, Texas Coastal Management Program, Texas General Land Office (1975 - 1979).

Governor's "208" Planning Advisory Committee, Corpus Christi Area, Office of the Governor (1976 - 1978).

Nueces River Basin Planning Advisory Committee, Texas Water Quality Board (1974 - 1975).

ORGANIZATIONS:

Houston Area Research Center, Center for Growth Studies, The 1988 Woodlands Conference, "New State Roles: Environment, Resources and the Economy", The Woodlands, Texas.

Texas Marine Resources Foundation, President (1982 -1987).

Keystone Hazardous Materials Transportation Conference, Keystone Center, Keystone, Colorado (1986).

Keystone Ocean Project, Keystone Center, Keystone, Colorado (1985 - 1986).

The Coastal Society (1981 - 1982).

Texas Environmental Coalition, Vice President (1980 - 1982), Research Chairman (1978 - 1979).

Coastal Bend Conservation Association, Corpus Christi, Texas, President (1973 - 1981).

Gulf Coast Fishermen's Environmental Defense Fund, Advisory Director (1978 - 1982).

ATTACHMENT B

Contentions Adopted By **Steven A. Frishman** In Accordance With Affidavit
NEV-SAFETY-8
NEV-SAFETY-41
NEV-SAFETY-120
NEV-SAFETY-132
NEV-SAFETY-133
NEV-SAFETY-134
NEV-SAFETY-135
NEV-SAFETY-137
NEV-SAFETY-138
NEV-SAFETY-139
NEV-SAFETY-140
NEV-SAFETY-162
NEV-SAFETY-173
NEV-SAFETY-191
NEV-SAFETY-194
NEV-SAFETY-199
NEV-SAFETY-200
NEV-NEPA-2
NEV-NEPA-3
NEV-NEPA-12
NEV-NEPA-13
NEV-NEPA-14
NEV-NEPA-20
NEV-NEPA-21
NEV-NEPA-22
NEV-MISC-4
NEV-MISC-5

Attachment 21

Affidavit of Stephan K. Matthäi

BEFORE THE U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
License Application to Construct a Geologic Repository at Yucca Mountain	)	

AFFIDAVIT OF STEPHAN K. MATTHÄI

I, Stephan K. Matthäi, the undersigned affiant, do hereby make the following statements based upon my own knowledge, information, and belief.

1. My name is Stephan K. Matthäi, and my curriculum vitae is attached to this Affidavit as Attachment A. I am executing this Affidavit in support of the State of Nevada Petition to Intervene as a Full Party (Petition) in the above-captioned proceeding.

2. Within the Petition are numerous contentions, each comprised of several paragraphs. I hereby adopt as my own opinions the statements contained within Paragraph 5 of those specific contentions identified in Attachment B to this Affidavit. I understand that attorneys for the State of Nevada will assign unique numbers to each of those contentions just prior to the filing of the Petition and will include those unique numbers in Attachment B.

Further, the affiant sayeth not.

Leoben am, 12. DEZ. 2008

Stephan K. Matthäi

The above-named affiant personally appeared before me this 15 day of December, 2008, and executed this affidavit.

Notary Public

My Commission expires: 16.08.2030

Dr. ... öffentlicher Notar Leoben / Steiermark

ATTACHMENT A

CURRICULUM VITAE

STEPHAN K. MATTHÄI

Chair of Reservoir Engineering,
Department of Mineral Resources and Petroleum Engineering,
Montan University of Leoben, Austria
Wk: +43 3842 402 3000,
Fax: +43 3842 402 8202

E-mail: stephan.Matthäi@unileoben.ac.at
Homepage: www.petroleumengineer.at
CSMP++ Wiki: csmp.ese.ic.ac.uk/wiki

Date of Birth: May 6th, 1963
Place of Birth: Mosbach, Germany
Sex/Marital Status: male / married, one child
Nationality: German
Languages: English, German, French, Italian

10/2008- present: Professor (Ordinarius) of Reservoir Engineering, Montan University of Leoben, Austria.
1/2001-9/2008: Governor's Lecturer, (formal title: Senior Lecturer) Department of Earth Sciences & Engineering, Imperial College London, South Kensington.
3/2005: Concours National de la Recherche, habilitation, (qualification) France.
10/96-12/2000: Research Associate (Wissenschaftlicher Mitarbeiter), Institut für Isotopengeologie und Mineralische Rohstoffe, Swiss Federal Institute of Technology, Zürich, Switzerland.
6/95-10/96: Postdoctoral Research Fellow, Rock Fracture Project (RFP), Department of Geological and Environmental Sciences, Stanford University, Stanford, California, USA.
4/94-6/95: Postdoctoral Research Fellow, Department of Geological Sciences, Snee Hall, Cornell University, Ithaca, New York, USA.
5/90-2/94: Ph.D, Research School of Earth Sciences, Australian National University, Canberra, Australia. Supervisors: Dr. Mike A. Etheridge and Dr. Stephen Cox. Advisor: Dr. Richard W. Henley.
PhD Thesis: **The Genesis of Intrusive-Related Hydrothermal Gold Deposits**.
10/83-2/90: Diplom, Master of Science, Eberhardt Karls University of Tübingen, Germany. Supervisor: Dr. Wolfgang Frisch.
Diplom Thesis: **Deformation and Mineralization History of Emplaced Backarc Basin Crust on the Argolis Peninsula (Greece).**

Current Research
In 2008/2009 my main brief at the Montan University of Leoben is to deliver courses and redesign the curriculum for the Batchelor in Petroleum Engineering and the International Masters in Reservoir Engineering. In parallel, I am assembling a new research team with the

skills required to address reservoir engineering / enhanced and tertiary recovery problems arising in geometrically complex reservoirs by means of multiphysics simulations on unstructured grids. At the same time, third party funding for my former research group at Imperial College London will continue as does my involvement in the industry consortium on “Improved Simulation of Fractured and Faulted Reservoirs” which I iniatiated there in 2002 together with Martin Blunt.

The focus of my Computational Hydrodynamics group at Imperial (3 PDRAs, 5 PhD students) was to understand the fluid flow and hydro-geo-mechanical couplings in structurally complex, naturally fractured systems such as hydrocarbon reservoirs and geothermal systems. The main goal of this research was to predict emergent phenomena which have a significant impact on the engineering and management of these systems. This mission will continue.

We investigate multi-phase flow and deformation by means of case-study research on exhumed fossil and submerged active systems. We develop, test, and refine process hypotheses for these systems by means of numerical simulations on very large unstructured grids using our own HPC software. Application examples include hydrothermal and geothermal systems, as well as nuclear waste and CO_2 repositories. We have developed a workflow to build, parameterize, simulate, and analyse highly realistic models of well-described sub-surface systems including discrete representations of fractures and faults. Numerical experimentation is facilitated by our original object-oriented finite-element finite-volume software, the Complex Systems Modelling Platform (CSMP++), which we also market commercially.

Research topics we have worked on over the last three years, include (1) relative permeability upscaling (for field-scale multiphase flow simulation) and the scale-variance of transport properties of fractured rock, see Figure 1, (2) stress-sensitivity of fractured hydrocarbon reservoirs, (3) unsteady convection in faults in geothermal reservoirs, (4) compressible steam and brine flow in intrusive-related hydrothermal systems, (5) applicability of percolation theory to actual fracture systems, (6) development and shape modification of fractures under stress including the effects of carbonate dissolution and precipitation, (7) the heat budget of Stromboli volcano, and (8) interpretation of well tests in the vadose zone aided by streaming potential data inversion. Much of this work is supported by the oil industry and government agencies in the UK and elsewhere.

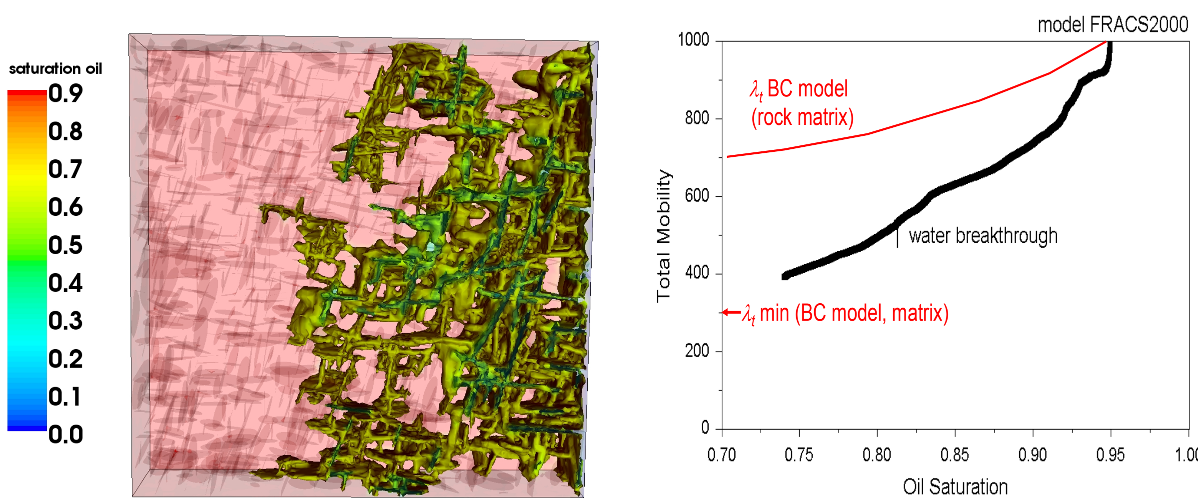

Fig. 1: Discrete fracture simulation example: (a) Waterflood of a 2 x 2 x 0.2 km model of a reservoir stochastically populated with 2000 fractures with a power-law diameter range

from 5 to 180 m (Matthäi et al., 2007); geological input data are from San Andreas formation (CA, USA, FRED model by Paul LaPointe, Golder Associates, Inc.). Aperture is consistent with field measurements and ranges between 0.5 and 3.5 mm correlating linearly with fracture diameter. (b) Evolution of total mobility in this model as compared with a Brooks-Corey curve for a strongly heterogeneous medium.

International Collaborations
(in alphabetical order sorted by last name and excluding industry sponsors)

Olivier Bildstein, Carderache (CEA), Aix-en-Provence, France

Raphael Blumenfeld, Cavendish Laboratory, Cambridge University, UK

Martin Blunt, Earth Science & Engineering, Imperial College London, UK

Tom Doe, Bill Dershowitz and **Steve Rogers,** Golder Associates Inc., Seattle, USA

Sebastian Geiger, Herriot-Watts University, Dept. Petroleum Engineering, Edinburgh, UK

Rainer Helmig, Institut Wasserbau, IWS, Technical University of Stuttgart, Germany

Chris Harris, Shell, USA, visiting professor at Imperial College London, UK

Thomas Driesner and **Chris Heinrich**, Institute for Isotope Geology and Mineral Resources, Swiss Federal Institute of Technology (ETH), Switzerland

Michael Hohmeyer and **Devendra Rajwade**, SimCosm Inc., Berkeley, CA, USA

Patrick Jenny, Institut für Maschinenbau, Civil Engineering, Swiss Federal Institute of Technology (ETH), Switzerland

Niklas Linde, Institute of Geophysics, Swiss Federal Institute of Technology (ETH), Switzerland

Yuri Olmelchenko and **Homa Karimibadi**, SciberQuest Inc., Dan Diego, CA, USA

André Revil, Colorado School of Mines, Golden, CO, USA

Steve Roberts, Centre for Mathematics and its Applications, Australian National University, Canberra, Australia

Klaus Stüben and **Tanja Clees**, FhG Forschungsinstitut SCAI (formerly Fraunhofer Ges.), Sankt Augustin, Germany

Kurt Stüwe, Geologisches Institut, Unversität Graz, Austria

Fernando Tornos, IGME, Salamanca, Spain

Fiona Whitaker, Earth and Environmental Sciences, Bristol University, UK

Academic Activities

Memberships
11/04-present, The Geological Society of London (GeolSoc)
9/04-present, Society of Petroleum Engineers (SPE)
11/85-present, American Geophysical Union (AGU)
4/98-present, European Geophysical Society (EGS)
11/03-present, Swiss Association of Petroleum Geologists & Engineers (ASP/VSP).

Reviewing for journals
Advances in Water Resources
American Association of Petroleum Geologists Bulletin
Economic Geology
Geofluids
Geophysical Research Letters
Journal of Geochemical Exploration
Journal of Geophysical Research
Journal of Structural Geology
Mineralium Depositae
SPE Journals
SGE Bulletin
Water Resources Research

For granting agencies
DOE (USA)
NERC (UK)
EPSRC (UK)
ARC (Australia)

Editorial boards
2000-present Associate editor: Geofluids, Blackwell Science Publications

Organised Conferences
several CSMP software development and modeling workshops, most recently, June 4-8 2007, Château de Meyrargues, France,
co-organiser and co-chair of SPE Forum on "Naturally Fractured Reservoirs", June 18-23 2006, Broomfield, CO, USA,
co-organiser 2007 SPE/EAGE Reservoir Characterization and Simulation Conference, October 28-31 2007, Abu Dhabi, UAE,
various sessions at past AGU meetings, for instance: "Modeling and Upscaling of Multiphase Flow in Fractured Rock Masses I, II (H12, H13) at fall meeting, December 10-14 2007, San Francisco, CA, USA.

Teaching
At Imperial, I have designed, coordinated, and am teaching courses in:
- Numerical Simulation of Hydrothermal Systems
- Heat and Mass Transfer (including lectures on geothermal systems and HDR)
- Igneous Petrology
- Metamorphic Petrology
- C++ Programming
- Handling and Display of Scientific Data
- a wide range of tutorials
- short courses for the oil, gas, and mining industry (for example in 2006: 3-day course on fractured reservoirs for ADNOC (Abu Dhabi) and Petrobras, Brasil). In October, I taught the

SPE/EAGE short course "*Simulation of Multiphase Flow in Naturally Fractured Reservoirs*," at the 2007 SPE/EAGE Reservoir Characterization & Simulation Conference, Oct 28th – 31st, Abu Dhabi, UAE. In February 2008, I will be teaching a similar course at the NIOC, Iran.

- workshops on geomodeling: model building in CAD, property assignment and configuration, discretization, and simulation for a range of software tools like GoCad.
- CSMP software courses for users and developers (graduate students, fellow academics, and industry people)

My Research Group

Associated with my chair are three postdoctoral research positions which I am trying to fill at present. In addition I have industry funding for two PhD projects for which I am in the process of recruitment.

At Imperial, I was leading a research group with 3 postdocs, 5 PhD students and, on average, 2 MSci students. I assist in the supervision of several other PhD students in Earth Science & Engineering.

PhD students

Lamb, A. 2007-present, "Formation and influence on fluid flow of polygonal faults in marl-carbonate sequences," co-supervised by Dr. L. Moen-Maurel, Total.

Maghami-Nick, H. 2007-present, "DFM simulation, and upscaling relative permeability in fractured reservoirs."

Iding, M., 2006-present, "Permeability effects of super-critical CO_2 migrating through fractured cap rock of gas reservoirs," co-supervised by Prof. H. Dahle, Norway.

Akanji, L., 2006-present, "Capillary pressure and two-phase flow in micro-fractures in a porous medium: numerical simulation case study."

Paluszny, A., 2005-present, "Mechanical modeling of fracture propagation and shape modification by dissolution – precipitation processes."

Tomlinson, R. 2005, "Understanding Hydrothermal Fluid Flow within Faults and Associated Mineralization Using a Combined Field and Numerical Approach."

Conde, C. 2005-present, "Formation of Giant Massive Sulphide Deposits in Iberian pyrite belt", Marie Curie Fellow from the University of Salamanca, Spain, co-supervised with F. Tornos, IGME.

Behbahani, H., 2004, "Co- and counter-current imbibition in fractured porous media," co-supervised by M. Blunt.

Geiger, S., 2004, "Numerical Simulation of the Hydrodynamics and Thermodynamics of NaCl-H2O Fluids," Departement Erdwissenschaften, Swiss Federal Institute of Technology, Zürich, Switzerland, co-supervised with T. Driesner and C. A. Heinrich.

Belayneh, M., 2003, "Analysis of natural fracture networks in massive and well-bedded carbonates and the impact of these networks on fluid flow in dual porosity medium," co-supervised with J. Cosgrove.

Garofalo, P. S., 2000, "Gold precipitation and hydrothermal alteration during fluid flow through the vein network of the mesothermal gold deposit of Sigma, Abitibi Belt, Canada," Departement Erdwissenschaften, Swiss Federal Institute of Technology, Zürich, Switzerland, co-supervised with C. A. Heinrich and J. Ridley.

Over the last eight years, I have also supervised two to three Imperial College MSci and Master students per year from the earth sciences and petroleum engineering, respectively.

Scholarships and Prizes

Overseas-student PhD scholarship (ORSPS) to study at the Australian National University awarded by the Australian government,

Dominion Mining Ltd, research scholarship for PhD research.

Research Grants

(only those obtained in current position)

Statoil, HDT initiative "Simulation of fault-related dolomitisation and micro-porosity generation", 115k GBP for postdoctoral project, awarded jointly to myself and Fiona Whitaker, Bristol University in January 2008,

ExxonMobil, (FC)2 project: "Effects of wettability alteration on recovery from naturally fractured carbonate reservoirs," 128k GBP, October 2007,

DTI-EPSRC, Technology Programme: "Improved simulation of oil recovery from fractured reservoirs," 502k GPB, January 2007, shared with co-investigator M. Blunt.

Total, PhD project: "Flow properties and genesis of polygonal faults in carbonate reservoirs." 93k GBP, October 2006,

Total, pilot study: "Well-test interpretation in fractured reservoirs," 10k GPB, October 2006,

ExxonMobil, membership of itf-ISF2 consortium (see below)", 90k GBP, September 2006,

Hydro, proof of concept study: "Benchmarks of gas flow through fractured reservoirs." 30k GBP, August 2006,

itf, oil industry consortium: "Improved simulation of faulted and fractured reservoirs 2," 421k GBP, January 2006,

Carderache, France, "Fracture and fluid flow in bentonite confining nuclear waste," 8k Eu, June 2005.

Golder Associates Inc., Seattle, USA, "Generation of a 2-phase flow simulator (CSP2PHFLOW Vs.1.0-beta) for FRED Fracture-Only Reservoir Models," 12k GBP, August 2003,

Golder Associates Inc., Seattle, USA, "Linking FRED with CSP: Simulating well tests and production from fractured reservoirs," 6k GBP, October 2001,

SHELL, Rijswik, proof of concept study: "Numerical simulation of capillary-driven flow in fractured carbonate reservoirs," 9k GBP, November 2003,

itf, oil industry consortium and DTI: "Improved Simulation of faulted and fractured reservoirs 1," 485k GBP+75k GBP in 2004 from PetroCanada, May 2002.

Publications

International Journals

add 2008 articles

1. Coumou, D., Matthäi, S.K., Geiger, S., and Driesner, T. “A parallel FE-FV scheme to solve fluid flow in complex geologic media,” Computers & Geosciences, in press (CAGEO-D-06-00378R2).
2. Matthäi, S.K., Mezentsev, A., and Belayneh, M., “Finite-Element Node-Centered Finite-Volume experiments with fractured rock represented by unstructured hybrid element meshes,” SPE Reservoir Evaluation & Engineering, 10:6, 740-756 (2007).
3. Linde, N., Jougnot, D., Revil, A., Matthäi, S.K., Arora, T., Renard, D., and Doussan, C., “Streaming current generation in two-phase flow conditions.” *Geophysical Research Letters* 34, L03306, doi:10.1029/2006GL028878 (2007).
4. Revil, A., Linde, N., Cerepi, A., Matthäi, S.K., and Finsterle, S., “Electrokinetic coupling in unsaturated porous media,” Journal of Colloid and Interface Science 313, 315 - 327, ISSN: 0021-9797 (2007).
5. Paluszny, A., Matthäi, S.K., and Hohmeyer, M., “Hybrid Finite Element Finite Volume Discretisation of complex geologic structures and a new simulation workflow demonstrated on fractured rocks.” *Geofluids* 7, 186-208 doi: 10.1111/j.1468-8123.2007.00180.x (2007).
6. Belayneh, M., Geiger, S., Matthäi, S. K., “Numerical simulation of water injection into layered fractured carbonate reservoir analogues.” *American Association of Petroleum Geologists Bulletin* 90, 1-21 (Oct 2006).
7. Geiger, S., Driesner, T., Heinrich, C. A., Matthäi, S. K., “Multiphase thermohaline convection in the earth’s crust: I. A new finite element - finite volume solution technique combined with a new equation of state for NaCl-H_2O.” *Transport in Porous Media* 63, 399 – 434 (2006).
8. Geiger, S., Driesner, D., Heinrich, C. A., Matthäi, S. K., Multiphase thermohaline convection in the Earth's crust: II. Benchmarking and application of a finite element - finite volume solution technique with a NaCl-H2O equation of state.” *Transport in Porous Media*, 63, 435-461, (2006).
9. Coumou, D., Driesner, T., Geiger, S., Heinrich, C. A. and Matthäi, S. K., “The dynamics of mid-ocean ridge hydrothermal systems: Splitting plumes and fluctuating vent temperatures.” *Earth and Planetary Science Letters* 245:1-2, 218-231 (May 2006).
10. Belayneh, M., Masihi, M., Matthäi, S. K., King, P., “Prediction of vein connectivity using the percolation approach: model test with field data,” *Journal of Geophysics and Engineering* 3, 219 – 229 (2006).
11. Geiger, S., Driesner, T., Matthäi, S. K., and Heinrich, C. A., “On the dynamics of thermohaline convection in the earth's crust.” *Journal of Geophysical Research* 110, B07101 (2005).
12. Geiger, S., Driesner, T., Heinrich, C. A., Matthäi, S. K., “Coupled heat and salt transport around cooling magmatic intrusions,” *Geochimica Cosmochimica Acta*, 69, A739 - A739 (2005).
13. Matthäi, S. K., Mezentsev, A. A., Pain, C. C., A high-order TVD transport method for hybrid meshes on complex geological geometry, *International Journal for Numerical Methods in Fluids*, 47, 1181-1187 (2005).

14. Geiger, S., Roberts, S., Matthäi, S. K., Zoppou, C. and Burri, A., "Combining finite element and finite volume methods for efficient multi-phase flow simulation in highly heterogeneous and geometrically complex porous media." *Geofluids*, 4, (2004).
15. Matthäi, S. K. and Belayneh, M., "Fluid flow partitioning between fractures and a permeable rock matrix" *Geophysical Research Letters*, 31:7, L07602, doi:10.1029/2003GL019027 (paper includes the magazine cover and was presented as an AGU publication highlight) (2004).
16. Matthäi, S. K., Heinrich, C. A., Driesner, T, "Is the Mount Isa copper deposit the product of forced brine convection in the footwall of a major reverse fault ?" *Geology* 32:4, 357-360 (2004). Also published reply to comment in Octobre 2004.
17. Matthäi, S. K., "Fluid flow and (reactive) transport in fractured and faulted rock" *J. Geochemical Exploration*, 78-79, 179-182 (2003).
18. Geiger, S., Roberts, S., Matthäi, S.K., and Zoppou, C., "Combining finite volume and finite element methods to simulate fluid flow in geologic media." *ANZIAM Journal 44(E)*, C180-201 (2003).
19. Geiger, S., Haggerty, R., Dilles, J. H., Reed, M. H., Matthäi, S. K., "New insights from reactive transport modelling: the formation of the sericitic vein envelopes during early hydrothermal alteration at Butte, Montana," *Geofluids* 2:3, 185-193 (2002).
20. Garofalo, P., Matthäi, S. K., Heinrich, C. A., "Three-dimensional geometry, ore distribution and time-integrated mass transfer through the quartz-tourmaline-gold vein network of the Sigma deposit (Abitibi belt, Canada)." *Geofluids* 2:3, 217-225 (2002).
21. Matthäi, S.K., invited review of "Fractures, Fluid Flow and Mineralization." *Geol. Soc. Spec. Publ.* 155, In *J. Structural Geology* 22:2, 277-280 (2000).
22. Weinberg, R. and Matthäi, S. K., invited review of "Deformation-enhanced fluid transport in the Earth's crust and mantle" Elsevier, Amsterdam, Netherlands. In *Tectonophysics*, 313:3, 329-332 (1999).
23. Matthäi, S.K., Aydin, A., Pollard, D. D., and Roberts, S. G., "Simulation of transient well-test signatures for geologically realistic faults in sandstone reservoirs" *SPE Journal*, 3:1, 62-76 (1998), SPE 38442.
24. Matthäi, S. K. and Roberts, S., "The influence of fault permeability on single-phase fluid flow near fault-sand intersections: Results from steady-state high-resolution models of pressure-driven fluid flow" *AAPG Bull.* 80:11, (1996), 1763-1779.
25. Matthäi, S. K., and Fischer, G., "Quantitative modeling of fault-fluid-discharge and fault-dilation-induced fluid-pressure variations in the seismogenic zone" *Geology* 24:2, (1996), 183-186.
26. Matthäi, S. K., and Henley, R. W., "Geochemistry and depositional environment of the gold-mineralized Proterozoic Koolpin Formation, Pine Creek Inlier, Northern Australia: A Comparison with Modern Shale Sequences" *Precambrian Research* 78, (1996), 211-235.
27. Matthäi, S. K., Henley, R. W., Heinrich, C. A., "Gold precipitation by fluid-mixing in bedding-parallel fractures near carbonaceous slates at the Cosmopolitan Howley gold deposit, Northern Australia" *Econ. Geol.* 90:8, (1995), 2123-2142.
28. Matthäi, S. K., Binns, R. A., Henley, R. W., Andrew, A. S., Carr, G. H., Bacigalupo-Rose, S., French, D. H., and McAndrew, J., "Intrusion-related, high-temperature gold-quartz veining at the Cosmopolitan Howley metasedimentary rock-hosted gold deposit, Northern Territory, Australia" *Econ. Geol.,* 90:5, (1995), 1012-1045.

29. Henley, R. W., Matthäi, S. K., and Kavanagh, M. E., "Hypothermal vein mineralisation at the Cosmopolitan Howley gold deposit, Northern Territory" The *Aus. IMM Bull.* 5, Sept. 1994, (1994).
30. v. Engelhardt, W., Matthäi, S. K., Walzebuck, J., "Araguainha impact crater, Brazil. I. The interior part of the uplift" *Metereotics* 27, (1992), 442-457.

Contributions to Books Edited by Others

1. Matthäi, S. K., Geiger, S., Roberts, S. G., Paluszny, A., Belayneh, M., Burri, A., Mezentsev, A., Lu, H., Coumou, D., Driesner, T., and Heinrich, C. A., "Numerical simulation of multi-phase fluid flow in structurally complex reservoirs, In: Jolley, S. J., Barr, D., Walsh, J. J., & Knipe, R. J., editor, Structurally Complex Reservoirs, Geological Society London Spec. Publ., 292, 405 – 429 (2007).
2. Belayneh, M, Matthäi, S K, Cosgrove, J, "The implications of fracture swarms in the Chalk of SE England on the tectonic history of the basin and their impact on fluid flow in high-porosity, low-permeability rocks," In: Ries, A. C., Butler, R. W. H. & Graham, R. H., editor, Deformation of the Continental Crust: Geological Society London Spec. Publ., 291, 499 – 517 (2007),
3. Matthäi, S. K., Roberts, S. G., Aydin, A., and Pollard, D. D., "Numerical simulation of departures from radial drawdown in a faulted sandstone reservoir with joints and deformation bands" *Geological Society of London, Spec. Publ.* 147 (1998), 157-191.
4. Matthäi, S. K. and Roberts, S., "Transient versus continuous fluid flow in seismically-active faults: An investigation by electric analog and numerical modelling" in "Fluid Flow and Transport in Rocks: Mechanisms and Effects" (Chapmann & Hall), (1996), 263-295.

Proceedings

1. Geiger, S, Matthäi, S K, Niessner, J, and Helmig, R, "Black-oil simulations for three component - three phase flow in fractured porous media," SPE Europec/EAGE Annual Conference and Exhibition, Richardson, Texas, USA, Society of Petroleum Engineering, 1 – 14 (2007),
2. Matthäi, S. K., Mezentsev, A., and Belayneh, M., "Control-Volume Finite-Element two-phase flow experiments with fractured rock represented by unstructured 3D hybrid meshes", SPE93341, Proc. SPE Reservoir Simulation Symposium, Houston Texas, 31 January – 2 February, (2005).
3. Matthäi, S. K., "Understanding the Influence of Faults and Fractures on Sub-Surface Fluid Flow: What can be achieved by Numerical Simulations Today ?" in "Fault Zone Characterization for Tectonic Numerical Modelling" Connolly, P. ed (Proc. Int. Workshop, 9-12th November, Frankfurt, Germany, 2001).
4. Matthäi, S. K. and Garofalo, "Three-dimensional shear zone and joint geometry and permeability in the Sigma Gold Mine, Canada" in Stanley, C. J. et al. ed (Proc. Fifth Biennal SGA Meeting and the Tenth Quadrennial IAGOD Symposium, London, Aug. 22-24th, London, 2, 1411-1414, 1999).
5. Matthäi, S. K., "Irregular alteration envelopes of mineralized fractures as a product of directed fluid flow and/or chemical dispersion ?" in "Mineral Deposits: Research and Exploration - Where do they meet ?", Papunen, H. ed (Proc. SEG Symposium, August 1997, Turku, Finland, 237-239, Balkema Rotterdam, 1997).

6. Roberts, S.G., and Matthäi, S.K., "High-resolution potential flow methods in oil exploration" in "Computational Techniques and Applications Conference" World Scientific Publications (Proc. Int. Conf. Melbourne, Australia, July 1995).

Technical Reports

1. Matthäi, S. K., "The State-of-the-Art in Upscaling of Two Phase Flow in Fractured Rock," NDA (formerly NIREX), UK, 72 p. (2007),
2. Geiger, S., Roberts, S., Matthäi, S. K., and Zoppou, C., "Modelling Multi-Phase Flow in the Earth's Crust using Node-Centered Finite Volumes on Unstructured Finite Element Grids" Math. Res. Rep. MRR01-023, The Australian National University, School of Mathematical Sciences, 16 p. (2001),
3. Roberts, S. G., and Matthäi, S. K., "High-resolution potential flow methods in oil exploration" Math. Res. Rep. MRR 003-96, Centre for Mathematics and its applications, School of Mathematical Sciences, Australian National University, Canberra, Australia, 9 p., (1996).

Non Refereed Publications

1. Matthäi, S. K., Geiger, S. and Roberts, S. G., "The Complex Systems Platform CSP5.0: User's Guide", 5th ed., ETH Research Reports, 150 p. (2004).

Selected Keynote Lectures

(selected international presentations from the last 5 years)

1. "Insights from numerical modeling of reactive fluid flow in fractured porous carbonate," Bilbao HDT workshop, September 17-20, Bilbao, Spain (2007),
2. "Upscaling multiphase flow in fractured reservoirs," SSGM Skill Area Symposium, ExxonMobile, Houston, TX, USA, October (2006),
3. "Fracture to field simulation of flow and transport," Gordon Research Conference on Flow and Transport in Permeable Media, Proctor Academy, NH, USA, July 30– August 4 (2006),
4. "Control-Volume Finite-Element two-phase flow experiments with fractured rock represented by unstructured 3D hybrid meshes", SPE Reservoir Simulation Symposium (RSS), Houston Texas, January 31– February 2, 2005,
5. "Modeling multiphase flow in fractured porous rock," Workshop on Modelling Coupled Processes in Porous Media, Utrecht University & TNO-NITG, September 19-20 (2005),
6. "Two-phase flow properties for numerical simulations with discrete fractures," Fractured Reservoirs Conference, The Geological Society, Burlington House, London, November 16-17 (2004),
7. "Discrete Fracture Simulation," SPE ATW Workshop, Society of Petroleum Engineers, Millenium Hotel, London, November (2003),
8. "Numerical simulation of multiphase flow in fractured reservoirs," Statoil Research Summit, Trondheim, September (2003),
9. "Fluid flow and transport in fractured and faulted rock," Geofluids IV conference, May 12-16 2003, Utrecht, The Netherlands (2003),
10. "Understanding the influence of faults and fractures on sub-surface fluid flow: what can today be achieved by numerical simulations?" Workshop on Fault Zone Characterization for Tectonic Numerical Modeling, Seeheim (Frankfurt), Germany, November 9-12 (2001).

Presentations

(selected international conferences during last 10 years)

1. “Numerical upscaling of relative permeability in fractured porous media,” AGU Fall Meeting, San Francisco, EOS Trans. AGU, 88(52), Fall Meet. Suppl.,Abstr. H12A-05 (2007),
2. “Characteristics of two-phase flow in complex fractured reservoirs: indications from Discrete-Fracture XFEM-FVM numerical experiments,” Complexity in the Oil Industry (COI2007), Natal, Brasil, August 5-9 (2007),
3. "Stress and fluid pressure sensitivity of the effective permeability of fractured hydrocarbon reservoirs,” DFG International Conference on Multifield Problems, Technical University of Stuttgart, October 4-6 (2006).
4. "Upscaling of water floods in fractured reservoirs via fracture-matrix flux ratio estimated by well testing,” IEA Collaborative Project: Enhanced Oil Recovery Workshop, Saint Germain en Laye, France, September 21-22 (2006).
5. “What can single-well constant-rate pump tests really tell about fractured rocks?” International workshop on Model Concepts for Fluid-Fluid and Fluid-Solid Interactions,” Freudenstadt, Germany, March 20-22 (2006),
6. "Upscaling water floods in fractured reservoirs via fracture-matrix flux ratio estimated by well testing,” Structurally Complex Reservoirs conference, Geological Society of London, London, February 28– March 2 (2006),
7. "Two-phase flow properties for numerical simulations with discrete fractures,” Fractured Reservoirs Conference, The Geological Society, Burlington House, London, November 16-17 (2004),
8. "Node-Centered control volume-finite-element simulation of multiphase flow in fractured rock," poster presentation, Gordon conference “Flow & Transport in Permeable Media”, Kings College, Oxford, UK, July 11-16 (2004),
9. "Implicit-pressure implicit-saturation CVFE simulation of multiphase flow in fractured rock," poster presentation, AGU Fall Meeting, San Francisco, December 7-11 (2003),
10. “Fluid-flow partitioning between fractures and matrix: numerical experiments for realistic fracture geometries,” AGU-EGS-EUG General Assembly, Nice, April 8-11 (2003),
11. “Rate-dependent recovery and water invasion in numerical models of fractured H.C. reservoirs,” Gordon conference “Flow & Transport in Permeable Media,” Proctor Academy, NH, USA, August 4-9 (2002),
12. “Drawdown-dependent recovery and water invasion in numerical models of fractured hydrocarbon reservoirs,” IMA conference on “Modelling flow in oil reservoirs,” BP Institute & Churchill College, Cambridge, UK, April 15-17 (2002),
13. “The Influence of deviatoric stresses in a deforming inhomogeneous rock pile on fluid flow in hydraulically-driven fractures,” European Geophysical Society, 25th General Assembly, Acropolis, Nice, France, 654 (2000),
14. “Three-dimensional geometry and permeability of gold-mineralized faults in the Sigma and Lamaque Mines, Quebec, Canada,” European Geological Union Meeting, March 28 - April 1, Strassbourg, France (1999),
15. “Fluid flow and reactant transport in anticlines,” European Geological Union Meeting, March 28 - April 1, Strassbourg, France (1999).

Software Engineering

Complex Systems Modeling Platform (CSMP++ vs. 6). Object oriented ANSI-ISO C++ application programmer interface (API) for simulation of complex process interactions in geometrically complex media. Currently 7 developers and >15 users, internationally:

Development history

1994: Idea of CSP at Cornell University, NY

Spring 1995: SKM's first implementation of CSP

Autumn 1995: Sabbatical of S.G. Roberts at Stanford University, CA, CSP with Meschach & AMG solver

1996: Review of CSP and suggestions by Bruce Eckel

1996-2000: Main development and implementation of CSP by SKM

2000-2001: S. Geiger develops FV capabilities, CSP-GoCAD interface

2001: CSP3D 4.0 in Std C++ using meta-template programming techniques

2001: ANSYS – CSP interface

2002: Design of IMP-IMPS capabilities and higher-order accurate transport scheme in collaboration with C. Pain; integration and interfacing with CFD tools

2003: SAMG-based large-scale mechanical calculations, generalized 3D IMP-IMPS multiphase flow capabilities including gravity drainage and capillary driven flow

2003: First commercial license is sold, distribution via ETHZ, Switzerland

2004: Introduction of DFEM methods to deal with discontinua, EOS for H_20-NaCl mixtures, simulation of two-phase brine-steam convection including boiling and condensation

2005: Parallelisation including SAMGp, fault zone convection model

2006: Generic node-centered FEFVM transport scheme, elasto-plastic deformation including a anisotropic damage model and smeared crack formulation, scaling analysis for parallel computations, prediction of fracture aperture from far-field stress. Documentation in DOxyen, see http://csmp.ese.imperial.ac.uk/wiki.

2007: CSP is renamed CSMP++ because of name clash with other commercial software tools, new prototype for run-time mesh adaptive, goal based simulations

2007: Introduction of XFEM techniques for the simulation of saturation discontinuities in multiphase fluid flow

2007: Completion of licensing agreements between ETHZ, Imperial, and team of CSMP developers, see http://www.transfer.ethz.ch/downloads/CSMP_licensing_Prices_final_071130.pdf

ATTACHMENT B

Contentions Adopted By **Stephan K. Matthäi** In Accordance With Affidavit
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