



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



# Ongoing and Planned Activities of the Office of the Chief Scientist – Baseline Program

Presented to:  
**Nuclear Waste Technical Review Board**

Presented by:  
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**January 24, 2007**  
**Las Vegas, Nevada**

# Outline

## Ongoing and Planned Activities

- **Scientific investigations supporting the License Application (LA)**
- **Focused areas of study**
  - Infiltration studies
  - Seismic ground motion studies
  - Volcanic hazard assessment update
  - Chlorine-36 ( $^{36}\text{Cl}$ ) investigations
- **Fostering intellectual continuity from repository licensing to closure**



# Scientific Investigations Supporting the LA

- **Expected model updates since Total System Performance Assessment-Site Recommendation (TSPA-SR)**
  - **Technical basis for TSPA-LA builds on the technical foundation documented for the TSPA-SR and TSPA-Final Environmental Impact Statement (TSPA-FEIS) models**
  - **Significant updates since TSPA-SR include**
    - ◆ **Changes to component models based on updated science (e.g., infiltration studies, new saturated zone borehole data)**
    - ◆ **Changes to the repository design, e.g., transportation, aging, and disposal (TAD) canisters**
    - ◆ **Extension of models for post-10,000 year analyses**
    - ◆ **Seismic scenario class included (TSPA-SR excluded seismic features, events, and processes based mainly on low consequence)**
    - ◆ **Enhanced treatment of aleatory and epistemic uncertainty**
    - ◆ **Additional analyses related to proposed 10 CFR 63 rule change**



# Scientific Investigations

## Supporting the LA (continued)

- **TSPA-input models and analyses expected to change**
  - **Science updates, requirements for post-10,000 year analyses, and additional model improvements**
    - ◆ **New infiltration studies: infiltration, unsaturated zone flow, calibrated properties, unsaturated zone radionuclide transport, unsaturated zone transport abstraction, drift seepage abstraction, multiscale thermohydrology**
    - ◆ **New Nye County Early Warning Drilling Program data and regional groundwater flow model update: hydrogeologic framework, saturated zone flow, saturated zone transport, saturated zone flow and transport abstraction**
    - ◆ **New igneous data: dike/drift interactions, atmospheric dispersal and deposition of tephra from a potential volcanic eruption, framework for igneous activity**
    - ◆ **New soil input parameters: biosphere**



# Scientific Investigations

## Supporting the LA (continued)

- **TSPA-input models and analyses expected to change (continued)**
  - **Design changes, requirements for post-10,000 year analyses, and additional model improvements**
    - ◆ **Drift-scale thermal-hydrologic-chemical seepage, in-drift convection and condensation, in-drift precipitates/salts, Engineered Barrier System (EBS) radionuclide transport abstraction**
    - ◆ **Dissolved concentration limits, in-package chemistry abstraction, waste form and in-drift colloids-associated radionuclide concentrations, waste package inventory allocation**
    - ◆ **Stress corrosion cracking of drip shield, waste package outer barrier, and stainless steel structural material; general corrosion and localized corrosion of waste package outer barrier; analysis of mechanisms for early waste package/drip shield failure**
    - ◆ **Seismic consequence abstraction, drift degradation analysis**
    - ◆ **Number of waste packages hit by igneous intrusion**



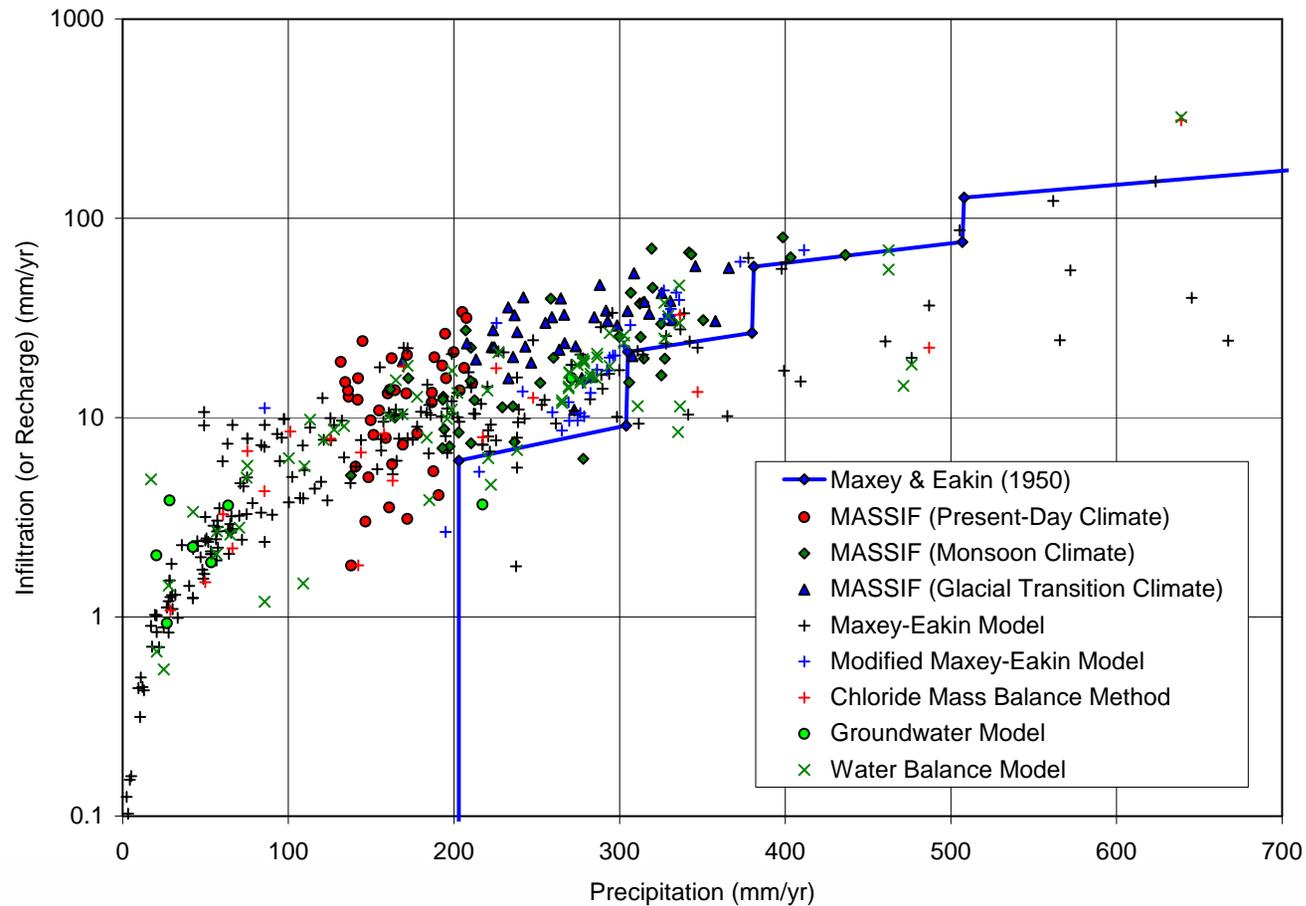
# Infiltration Studies

- **In Fiscal Year (FY) 2005 Sandia National Laboratories assembled a team to develop a replacement infiltration model**
- **New infiltration model (named MASSIF) is being documented in a complete revision to the model report *Simulation of Net Infiltration for Present-Day and Potential Future Climates* (MDL-NBS-HS-000023)**
- **Preliminary results indicate that the new infiltration rates are higher than the previous infiltration model result, but fall within the range of recharge estimates for groundwater basins in Nevada**



# Infiltration Studies (continued)

## Comparison of Recharge Estimates for Nevada Hydrographic Areas/Subareas with Preliminary MASSIF Estimates of Net Infiltration at Yucca Mountain



**Preliminary**



# Infiltration Studies (continued)

- **Sensitivity analysis with the new infiltration model shows most important parameters are the soil depth, soil water-holding capacity, and precipitation**
- **Differences between the previous infiltration model and the new model can be attributed in part to the following:**
  - **More thorough treatment of uncertainties associated with soil and rock properties (e.g., soil depth, soil hydraulic properties, near-surface bedrock permeability)**
  - **New model does not account for evapotranspiration from bedrock below the soil zone. This is a limitation due to insufficient data, but the approach yields reasonably conservative estimates of infiltration**
- **Revised infiltration rates will lead to revisions to unsaturated zone flow and transport models, drift seepage abstraction model, multiscale thermohydrology model, and TSPA**
- **Final report will be completed in June 2007**



# Seismic Studies

- **Preclosure objectives**
  - **Provide a seismic hazard curve for the surface facilities area that is to be used in a probabilistic analysis demonstrating preclosure performance, consistent with 10 CFR 63.111 requirements**
  - **Update preclosure ground motions to reflect additional geotechnical data for the surface facilities area and repository block**
  - **Continue geotechnical investigations to enhance confidence in surface facility area properties for licensing defense**



# Seismic Studies (continued)

- **Update preclosure seismic ground motions**
  - Incorporate additional geotechnical data collected since 2001
  - Develop a seismic hazard curve for the surface facilities area
  - Incorporate approaches to reasonably bound extreme ground motion at Yucca Mountain
  - Results to be documented in a revision of *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV (MDL-MGR-GS-000003)*



# Seismic Studies (continued)

- **Continue geotechnical testing**
  - **Supports licensing defense**
  - **Surface facility area boreholes**
    - ◆ **Provide additional geologic data on underlying units**
    - ◆ **Facilitate additional downhole velocity testing**
  - **Expand Spectral Analysis of Surface Wave (SASW) survey coverage of surface facility area**
  - **Additional downhole velocity surveys in existing boreholes on the repository block**
  - **Dynamic property testing of larger alluvium and tuff samples to better understand size effects**
  - **In situ dynamic property testing of alluvium**



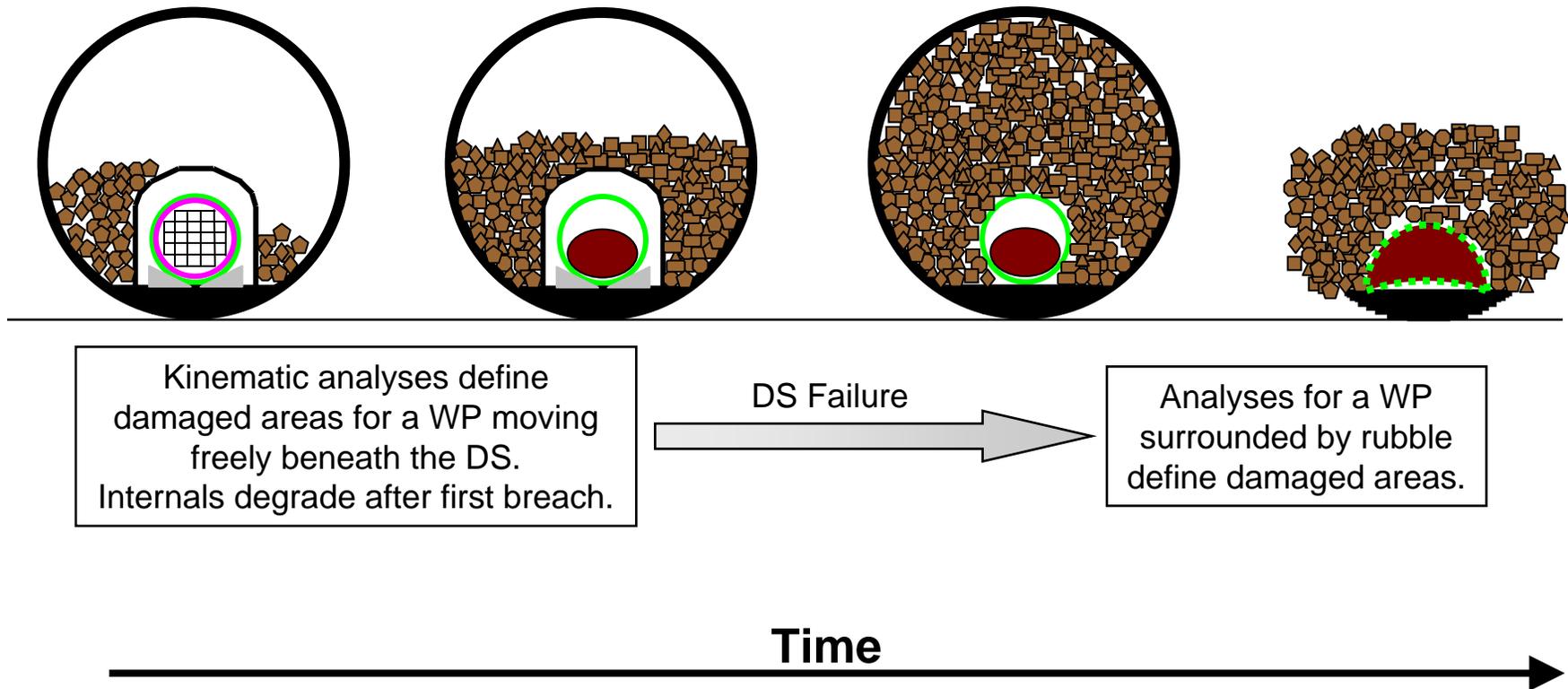
# Seismic Studies (continued)

- **Postclosure objectives**
  - Explicitly represent the TAD canister and its overpack
  - Consider degraded states of the waste package (WP), drip shield (DS), and drift beyond 10,000 years
    - ◆ Reduced thickness of components from general corrosion
    - ◆ Accumulation of rockfall in the drifts
  - Consider other failure modes for WP and DS
    - ◆ Rupture of the outer corrosion barrier of the WP
    - ◆ Rupture of the DS plates
    - ◆ Buckling of the DS framework
  - Include cumulative effects from multiple events



# Seismic Studies (continued)

## Typical Future States of the EBS



# Seismic Studies (continued)

- **Kinematic analyses**
  - Determine damage when WPs free to move beneath intact DS
- **DS damage analyses**
- **Analysis of DS failure modes**
  - Probability of rupture of DS plates and probability of buckling of DS framework
- **Analyses of WP surrounded by rubble**
  - Determine damage when DS has failed and WP is surrounded by rockfall
- **Update *Seismic Consequence Abstraction***
  - Prepare WP and DS damage abstractions
  - Update damage abstractions for fault displacement



# Volcanic Hazard Assessment Update

## Context for PVHA-Update

- **Probabilistic volcanic hazard analysis (PVHA) conducted in 1996 using formal expert elicitation process and it provides the basis for the LA**
- **DOE has made a regulatory commitment to complete a program of field studies (aeromagnetic survey, drilling, and sampling), data analysis, and an update to the PVHA**
- **PVHA-Update will confirm the licensing basis for, and characterization of, the volcanic hazard analysis**
- **Documentation will be provided in FY 2008**



# Volcanic Hazard Assessment Update

## Elements of PVHA-Update

- **Data collection and analysis**
  - **Low-altitude helicopter-borne aeromagnetic survey carried out to increase resolution related to potential buried basalts**
  - **Drilling of seven anomalies to determine origin of anomalies, depth, and age**
  - **Laboratory analyses of basalt age (K-Ar,  $^{40}\text{Ar}$ - $^{39}\text{Ar}$ ) and geochemistry**
  - **Key results of data collection**
    - ◆ **Results of aeromagnetic survey and drilling confirm understanding of spatial patterns of volcanism known at time of 1996 PVHA – no buried Pliocene or Pleistocene basalts to east of Yucca Mountain in Jackass Flats**
    - ◆ **As expected, drilling confirms not all anomalies due to buried basalt: 3 of 7 anomalies due to faulted Miocene tuff; only 1 anomaly (G) due to buried Pliocene basalt (3.8 Myr in northern Amargosa Desert), others are older than 9 Myr**



# Volcanic Hazard Assessment Update

## Elements of PVHA-Update (continued)

- **Expert Elicitation Process**
  - **Formal structured expert elicitation process (see schedule)**
    - ◆ **Data dissemination**
    - ◆ **Field trip, workshops, expert interactions**
    - ◆ **Individual expert interviews, followed by feedback**
  - **Result: probability of igneous events that could disrupt the repository**
    - ◆ **Will not be available for use in the LA but will support LA review**
    - ◆ **Documented in PVHA-Update report and update to the igneous framework analysis report**



# Volcanic Hazard Assessment Update Schedule

Activity	Schedule
Planning	July to September 2004
Select and Retain Experts	August to September 2004
Distribute Information to Experts for Review	September 2004
Workshop 1 Key Issues and Available Data	October 11 to 15, 2004
Workshop 2 Alternative Models	February 15 to 18, 2005
Workshop 2A Approaches to Volcanic Hazard Modeling	August 30 to 31, 2005
Field Trip to Event-Definition Analogue Sites	May 2 to 4, 2006
First Round of Elicitation Interviews	July to August 2006
Workshop 3 Preliminary Expert Assessments	September 26 to 27, 2006
Second Round of Elicitation Interviews	November to December 2006
<b>Preliminary Hazard Calculations and Sensitivity Analyses</b>	<b>January to April 2007</b>
Workshop 4 Feedback	May 2007
Experts Finalize Elicitation Summaries	June 2007
Final Hazard Calculations and Aggregation of Expert Assessments	June 2007 to January 2008
<b>Report Preparation/Finalization</b>	<b>November 2007 to June 2008</b>

Complete



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations Background

- In 1996, LANL investigators reported they had detected high values of  $^{36}\text{Cl}/\text{Cl}$  ( $>1250 \times 10^{-15}$ ) in rock samples from the Exploratory Studies Facility (ESF), indicating that some fast pathways for water movement exist from the surface to at least the depth of the ESF
- Subsequently, DOE conducted a peer review of the LANL results that recommended additional studies in their 1998 report



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations

## Validation Studies

- **In 1999, DOE initiated confirmatory studies led by scientists at the U.S. Geological Survey (USGS) and Lawrence Livermore National Laboratory (LLNL), with participation by Los Alamos National Laboratory (LANL) (August 2006 Report)**
  - **USGS/LLNL results did not replicate the earlier results**
  - **LANL results replicated earlier results for one location**
- **In 2003, DOE launched an independent study of all the  $^{36}\text{Cl}$  studies (July 2006 Report)**
  - **Nevada System of Higher Education/Harry Reid Center (NSHE/HRC) with scientists at University of Nevada, Las Vegas (UNLV) and New Mexico Institute of Mining and Technology**



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations

## Validation Studies (continued)

- **USGS, LANL, LLNL, and Atomic Energy of Canada Limited conducted a joint validation study**
  - **August 2006: *Chlorine-36 Validation Study at Yucca Mountain, Nevada*, TDR-NBS-HS-000017 Rev 00**
    - ◆ <http://ocrwm.doe.gov/documents/design/35641/index.htm>
  - **Documents the joint validation study including previous studies, methodologies used to analyze samples and evaluate all results, results, and conflicting interpretations**
  - **Discusses tritium ( $^3\text{H}$ ) and  $^{36}\text{Cl}$ ; study conclusions and recommendations**



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations

## Validation Studies (continued)

- **NSHE/HRC for Environmental Studies at UNLV completed a follow-on study**
  - **July 2006: *Bomb-Pulse Chlorine-36 at the proposed Yucca Mountain Repository Horizon: An Investigation of Previous Conflicting Results and Collection of New Data***
    - ◆ <http://hrc.nevada.edu/QA/Report/TR-06-002.pdf>
  - **Addresses sample collection, methodologies used to analyze and evaluate results**
  - **Examines  $^{36}\text{Cl}$ , Technetium ( $^{99}\text{Tc}$ ) and Iodine ( $^{129}\text{I}$ ) occurrence; study results and comparative discussion of project results, conclusions, and recommendations**



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations Validation Studies Summary Results

- **USGS/LLNL *did not* find elevated values of  $^{36}\text{Cl}/\text{Cl}$  ( $>1250 \times 10^{-15}$ ) in samples from around the Sundance Fault Zone as previously reported by LANL**
- **LANL confirmed their earlier reported elevated values only for Niche 1 samples**
- **LANL reported elevated values of  $^{36}\text{Cl}/\text{Cl}$  at several locations in the Enhanced Characterization of the Repository Block (ECRB) Cross Drift**
- **NSHE/HRC reported elevated  $^{36}\text{Cl}/\text{Cl}$  in only one rock sample from the ESF (Topopah Spring unit below the Paintbrush sequence)**
- **NSHE/HRC reported detectable levels of  $^{99}\text{Tc}$  in 6 of 9 rock samples from the ESF**



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations

## Possible Implications of Investigations

- **For unsaturated rocks,  $^{36}\text{Cl}$  measurements are difficult, and interpretation of results is challenging. Causes may include**
  - **Sample contamination**
  - **Heterogeneous local distribution of chloride**
    - ◆ **Micro-environmental controls on occurrence are complex**
- **Bomb-pulse  $^{36}\text{Cl}$  detections at a limited number of locations of the ESF indicate presence of few fast flow paths within the repository host rock**



# Chlorine-36 ( $^{36}\text{Cl}$ ) Investigations

## Project Treatment of $^{36}\text{Cl}$ Data

- **The current unsaturated flow and transport models reflect the  $^{36}\text{Cl}$  data in a reasonable and conservative manner. A sensitivity analysis indicates that fast and transient flow paths carry about 1% of the water (primarily through faults and fractures), and do not significantly affect the overall flow paths in the unsaturated zone**
- **Therefore, the Project has neither ongoing work nor plans for further study of the  $^{36}\text{Cl}$  issue**



# Fostering Intellectual Continuity from Repository Licensing to Closure

- **Program challenges**
  - **Ability to attract and retain “best and brightest”**
    - ◆ Aging population of experienced management, engineering, scientific, and other technical staff; significant learning curve for development of productive workers
    - ◆ Identifying and attracting candidates to mentor; providing engineering, scientific, and other technical staff with career development opportunities
  - **Balance short-term project work and goals with long-term needs and goals in a multifaceted, multigenerational program**
    - ◆ Enhance management approach to conduct of both short-term and long-term work (engineering, scientific, technical work, research and development, international program activities, etc.)



# Fostering Intellectual Continuity from Repository Licensing to Closure

- **Program goals**
  - **Seek excellence in documentation to enhance clarity, transparency, and traceability**
  - **Publications of Project documents in peer-reviewed literature (e.g., Site Description and GSA Memoir); conference participation**
  - **OCRWM Science and Technology Program**
  - **Monitor U.S. Research and Development**
  - **Foster development of research capabilities and cooperative work with Nevada institutions**
  - **Continued participation with international groups, seminars, studies, etc., with focus on resolution of geologic disposal issues**
  - **Provide repository program with scientific, management, and institutional continuity (e.g., Lead Lab)**

