NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: THREE-DIMENSIONAL SITE-SCALE MODEL OF UZ FLOW AT YUCCA MOUNTAIN

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Coworkers

- C. Wittwer, LBL
- G. Chen, LBL
- M. Chornack, USGS
- A. Flint, USGS
- L. Flint, USGS
- E. Kwicklis, USGS
- R. Spengler, USGS
- C. Rautman, Sandia
Presentation Overview

- Objectives of the study
- General approach
- Data needs and contributions from other studies
- Numerical modeling approach
- Results to date
- Current work
- Future work
- Credibility of the study
Why a Model?

- The 3-D model will integrate the available data and information on Yucca Mountain.
- The 3-D model will provide estimates of moisture, heat, and gas flow within the mountain.
- The 3-D model will be used to guide in the site-characterization effort ("enough" or "more" data).
Why a Model?
(Continued)

• The 3-D model will be used in sensitivity studies of the effects of spatial and temporal infiltration variations

• The 3-D model will be used to predict effects of future climate changes on moisture, heat, and gas flow within the unsaturated zone
Model Area

[Map of the area around the Nevada Test Site with labels for various locations including Amargosa Desert, Nevada Test Site, and Crater Flat.]

Best Available Copy
Areal Extent of the Site-Scale Model

Solitario Canyon Fault

Potential repository

Major fault
Secondary fault

1 km

Abandoned Wash Fault

Best Available Copy
How will we Proceed?

• General approach

• Important hydrogeologic issues

• Model development steps
Data collection and analysis

Selection and development of numerical codes

Data integration

Conceptual model

Peer review

Uncertainty analysis

Site-scale numerical model

Sub-models hypotheses testing

Performance assessment

Additional data needs
Some Site-Scale Modeling Issues

- Uncertainties in flux determination
- Densely fractured welded units; millions of fractures and matrix blocks
- Flow characteristics of major faults (e.g. Ghost Dance Fault)
- Matrix vs. fracture flow
- Gas flow (air + water vapor)
- Thermal effects on fluid flow
- Lateral flow and perched water
- Fracture and capillary barriers
Model Development Steps

- Development of a moisture flow model
- Incorporation of geothermal gradient
- Incorporation of gas flow components
- Periodic calibration of model against observed data (moisture tension, saturation, gas pressure, temperature, chemical concentrations)
- Periodic use of model for prediction of state variables at new well locations
- Periodic use of model for sensitivity studies of further data needs ("enough or not")
- Continuous use of submodels for hypothesis testing
What Data are Essential?

- Data needs and contribution of other studies
- Hydrogeologic maps
- Important hydrological parameters
3-D Site-scale model

Matrix properties
A. Flint

Fracture properties
L. Anna; G. Lecain

State variables
J. Rousseau

Infiltration
A. Flint

Chemical concentrations
A. Yang

Geological framework
R. Spengler

Saturated zone data
P. Tucci
How will We “Grid” the Mountain?

- Factors controlling horizontal gridding
- Factors controlling vertical gridding
- Incorporation of faults and fractures
- Flexibility for grid modifications
- Development of new simulation techniques
Simplified Map of Infiltration Zones and Outcrops

- Alluvium
- Ridgetop

Topopah and Paintbrush outcrops
Development of New Simulation Techniques

- Decoupling of TOUGH
- Analytical fracture/matrix model
- Numerical fracture/matrix grid generator
Flexibility for Grid Modifications

- The three-dimensional grid is *almost completely* computer-generated
- Some manual patching of grid elements near faults is necessary
What Have we Learned so Far?

- Two-dimensional simulation
- Effects of major faults
- Other important issues
Semi-Analytical Dual-Porosity Model

"Old" method
Fully discretized matrix blocks

"New" method
Semi-analytical sink/source term

Best Available Copy
Sect. B, Inflow = 0 mm/yr, $k_f = 10^{-11}$ m$^2$
Sect. B, Inflow = $10^{-3}$ mm/yr, $K_f = 10^{-11}$ m$^2$
Sect. B, Inflow = $10^{-3}$ mm/yr, $k_f = 10^{-11}$ m$^2$
Sect. B, Inflow = $10^{-1}$ mm/yr, $K_f = 10^{-11}$ m$^2$
Sect. B, Inflow = $10^{-1}$ mm/yr, $k_f = 10^{-11}$ m$^2$
Sect. B, Inflow = 5 \times 10^{-1} \text{ mm/yr}, K_f = 10^{-11} \text{ m}^2
Sect. B, Inflow $= 5 \times 10^{-1}$ mm/yr, $k_f = 10^{-11}$ m$^2$
Sect. D, Inflow = $10^{-1}$ mm/yr, $K_f = 10^{-20}$ m$^2$
Sect. D, Inflow = $10^{-1}$ mm/yr, \( K_f = 10^{-20} \text{ m}^2 \)
What are We Doing Now?

• Moisture flow report
• Investigation of grid effects
• 3-D simulations
Where are We Going?

- Incorporation of geothermal gradient
- Incorporation of gas flow
- Development of predictive capability
- Model sensitivity ("enough data")
- Tool for performance assessment
Why is the Work Technically Sound?

- Quarterly modeling meetings
- Publications in International High Level Radioactive Waste meetings and refereed journals
- Periodic peer review (LBL, USGS, DOE, NRC, NWTRB, etc.)
- Documentation through USGS QA program
Summary

• 3-D site-scale model under development

• Major purpose of model to *integrate* the available data and to *guide* in the site-characterization process

• Model will address sensitivity of infiltration changes both spatially and temporally and predict the effects of future climate changes