[6]

KEY TECHNICAL ISSUE

UNSATURATED & SATURATED FLOW UNDER ISOTHERMAL CONDITIONS

NRC/DOE TECHNICAL EXCHANGE
PRE-LICENSING ISSUE RESOLUTION
APRIL 25-26, 2000
LAS VEGAS, NV

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Legacy/main-xu

SUBISSUES AND STATUS OF RESOLUTION

1: Climate Change (CLOSED)

2: Hydrologic Effects of Climate Change (CLOSED)

3: Present-Day Shallow Infiltration (CLOSED)

4: Deep Percolation (Present-Day and Future) (OPEN)

5: Ambient flow in the saturated zone and dilution (OPEN)

6: Matrix Diffusion (OPEN: nearing resolution)

Subissue 1: Climate Change

- **RSS Principal Factor: limited seepage into drifts**
- **NRC abstraction: spatial & temporal distribution of flow**

STATUS: CLOSED (based on TSPA-VA review)

Subissue 2: Hydrologic Effects of Climate Change

- RSS Principal Factors: limited seepage into drifts
- NRC abstraction: spatial & temporal distribution of flow; flow paths in the saturated zone

STATUS: CLOSED (based on TSPA-VA review)

Subissue 3: Present-day Shallow Infiltration

- RSS Principal Factors: limited seepage into drifts
- NRC abstraction: spatial & temporal distribution of flow

STATUS: CLOSED (based on TSPA-VA review)

Subissue 4: Deep Percolation (Present-day and Future)

RSS Principal Factors: limited seepage into drifts; retardation in the unsaturated zone

NRC Abstractions: spatial & temporal distribution of flow; quantity & chemistry of water contacting waste packages; flow paths in the unsaturated zone

Seepage into drifts has a potentially large effect on repository performance because it controls the amounts of water that can contact drip shields and waste packages

STATUS: OPEN

Need for Additional Data and Analysis

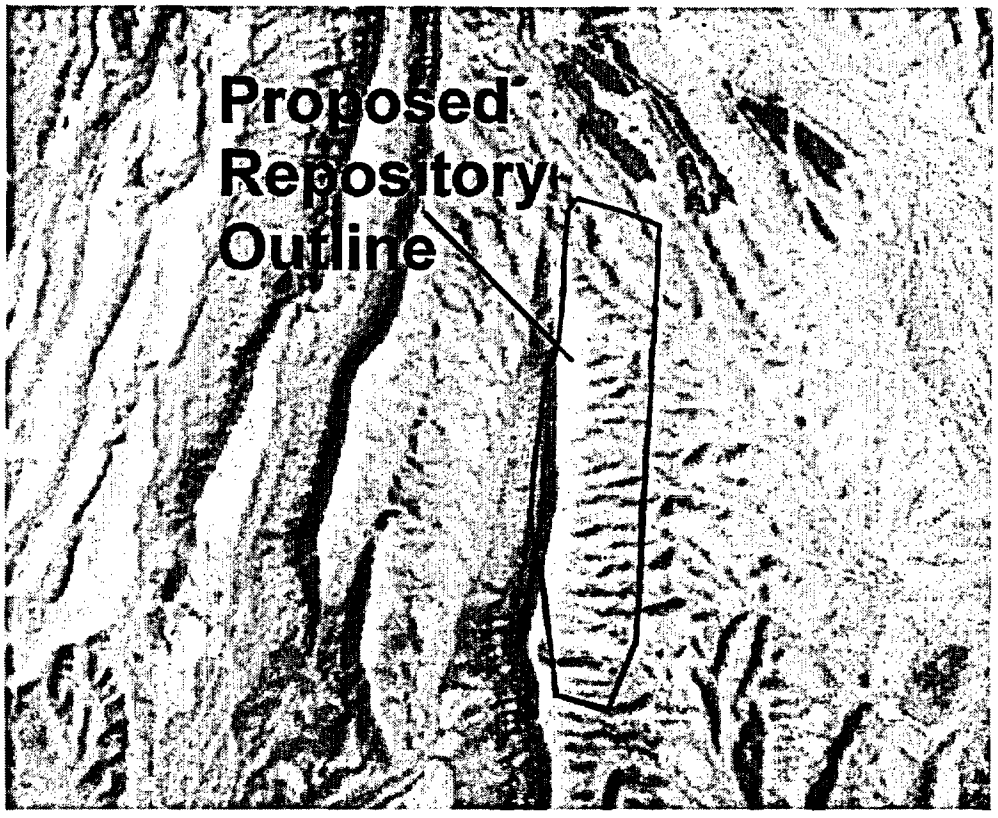
<u>Spatial Distribution of Deep Percolation (Above the Repository)</u>

- Determine UZ matrix moisture potentials under natural conditions (needed to calibrate UZ models)

- Justify key assumptions, or show they have little effect on performance

  Assumption: Steady-state infiltration and percolation - dampening of pulses by PTn layer is basis for steady-state flow assumption, but:

  (1) part of the repository west of Yucca crest has no overlying PTn, and


Proposed
Repository
Outline

(2) perched water chemistry & CL-36 data suggest significant flux bypasses the PTn (models need to be consistent with Cl-36 data)

Assumption: Intra-layer homogeneity (heterogeneity may cause lateral diversion or focusing, e.g., Pruess, 1999)

- Include effects of surface-water routing on infiltration and percolation

<u>Seepage into Underground Openings</u>

- Possible path to resolution: conservatively assume the fraction of percolation that intercepts footprint area of waste packages will contact them (or their drip shields)

  Or, reduce this fraction by making observations of drift seepage under natural conditions - this would estimate how much percolation is diverted away from drifts - needed because we see problems in DOE's approach:

  Concept of seepage threshold - minerals in lithophysal cavities suggest seepage occurs even in openings much smaller than drifts (Hughson and Codell, 2000)

  DOE has not considered drift collapse and other isothermal changes in wall rock

Drift seepage models use a grid with a ~0.5 m spacing. The basis for assumed fracture properties at this scale is unclear.

Flow Paths in the Unsaturated Zone Below the Repository

- UZ model calibrations should be consistent with *in situ* data that show rock matrix is wetter & moisture more evenly distributed than expected

- Hydraulic properties and vitric/zeolitic content of Calico Hills must be based on borehole and perched water data; models should predict creation of perched water

- How will DOE address comments from external peer review groups (US Nuclear Waste Technical Review Board, peer review of TSPA-VA, drift seepage peer review, and expert elicitation for the UZ)?

Subissue 5: Saturated Zone and Dilution

RSS Principal Factors: retardation in the SZ; dilution during migration

NRC Abstractions: flow paths in the saturated zone; dilution due to well pumping

Properties of the SZ (especially alluvium) have a large effect on performance, and compliance must be shown at downgradient locations where groundwater is pumped from the SZ

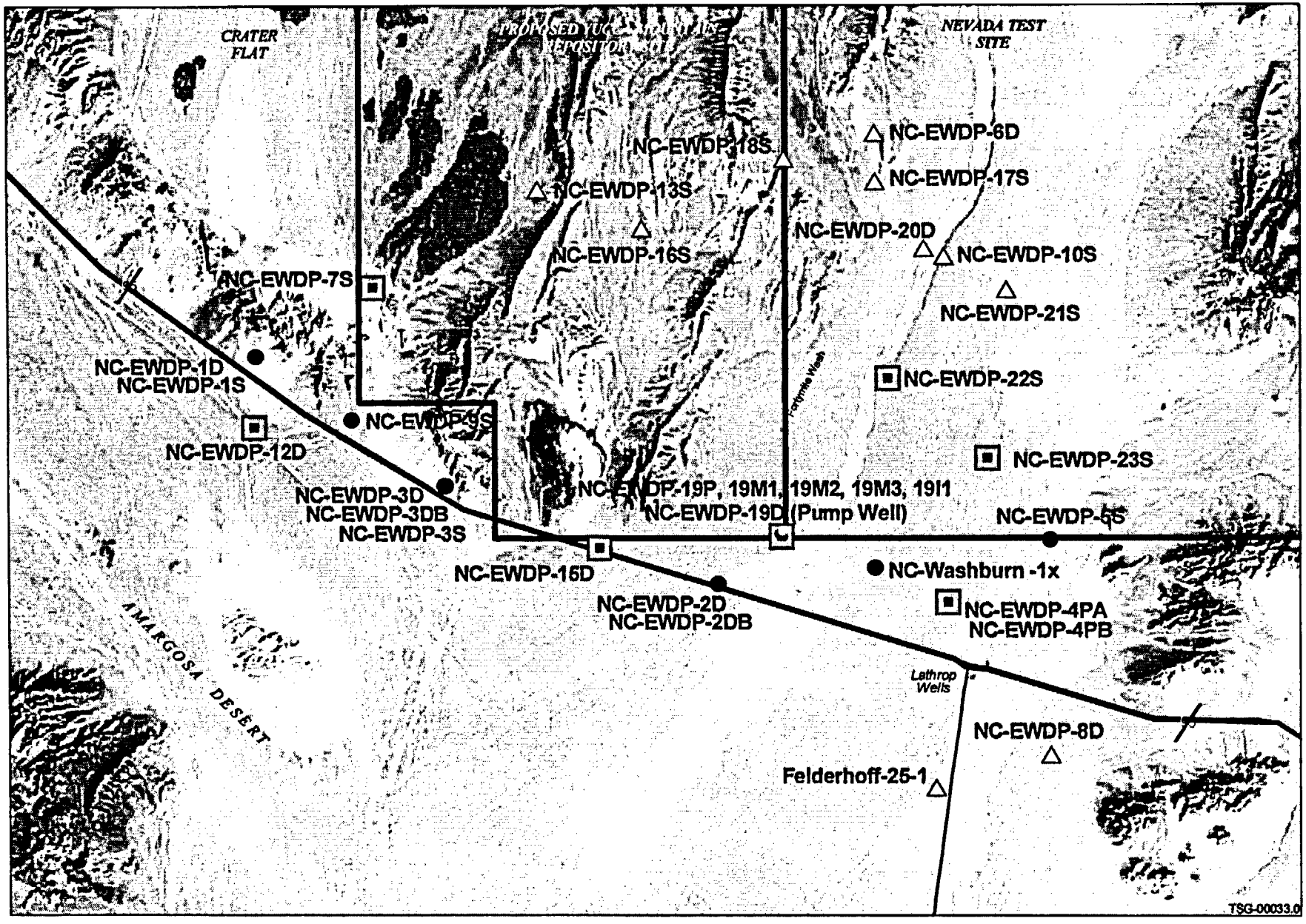
STATUS: OPEN

Need for Additional Data and Analysis

- Show where the water table transitions from the tuffs to valley fill, or conservatively use the shortest lengths of alluvial transport paths that can be justified

- Provide and analyze data from the C-holes, SD-6, and WT-24; obtain hydraulic conductivity & effective porosity for saturated valley fill at 20-km and in data gaps to the south; performance seems more sensitive to properties of alluvial flowpaths than to those of tuffs

- Do C-14 dating of organic carbon in groundwater from the SZ to estimate residence times (independent check on regional flow models)



NYE COUNTY, NEVADA

EARLY WARNING DRILLING PROGRAM DRILLHOLE LOCATIONS

0 1 2 3 4 5 6 7 8 9 10 Miles

- Phase I Drillholes
- Phase II Drillholes
- Phase II Monitoring Wells
- Phase II Injection Well
- Phase III Drillholes

- For SZ models, include horizontal anisotropy in hydraulic conductivity for tuffs

- Develop revised potentiometric maps that include Nye County data; enough groundwater elevation data should be available to reasonably bound the direction of lateral flow from the repository

- Consider future water-table rise in performance assessments; We are closely tracking results of the UNLV fluid inclusion study, which relates to water-table rise.

- If DOE takes credit for wellbore dilution, as mentioned in TSPA-SR (methods & assumptions), provide analysis

- How will DOE address external peer review comments? For example, the SZ expert elicitation criticized the adequacy of SZ models.

Subissue 6: Matrix Diffusion

RSS Principal Factors: retardation in the UZ and SZ

NRC Abstractions: unsaturated and saturated zone transport

Matrix diffusion appears of secondary importance to performance.

STATUS: OPEN (nearing resolution)

Need for Additional Analysis

<u>Unsaturated Zone</u>

- If credit is taken for UZ diffusion, explain patterns in pore water chemistry that suggest limited diffusion. Pore water chemistry suggests matrix diffusion in UZ not very effective, except perhaps in perched zones

- In the VA, sensitivity studies suggest the UZ matrix diffusion has a small effect on performance

- Possible path to resolution: take little credit for UZ matrix diffusion; otherwise, explain patterns in pore water chemistry

Saturated Zone

- Lab analyses, tracer tests, and analysis of flow interval spacing give sound basis for SZ matrix diffusion

- Possible path to resolution: NRC will review SZ Process Model Report to evaluate approach to matrix diffusion in SZ transport modeling and other parameter estimates

SUMMARY TABLE			
SUBISSUE IN ISOTHERMAL HYDROLOGY	RESOLUTION STATUS	RELATED NRC ABSTRACTIONS	RELATED DOE PRINCIPAL FACTORS
Climate change	Closed	spatial & temporal distribution of flow	limited seepage into drifts
Hydrologic effects of climate change	Closed	spatial & temporal distribution of flow; flow paths in the SZ	limited seepage into drifts
Present-day infiltration	Closed	spatial & temporal distribution of flow	limited seepage into drifts
Deep percolation	Open	spatial & temporal distribution of flow; quantity & chem. of water contacting WPs; flow paths in UZ	limited seepage into drifts; retardation in UZ
Flow in the saturated zone and dilution	Open	flow paths in the SZ; dilution due to well pumping	retardation in SZ; dilution during migration
Matrix diffusion	Open (nearing resolution)	UZ transport; SZ transport	retardation in UZ; retardation in SZ