

# Report on Recent Site Investigations

Presented to:  
Nuclear Waste Technical Review Board

Presented by:  
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M&O/LANL



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

January 26-27, 1999

# Overview

- **ESF Testing**
  - Infiltration/Percolation testing
  - Thermal testing
- **Cross Drift**
  - Lithostratigraphic predictions and results
  - Moisture monitoring results
  - Current plan
- **Busted Butte**
  - Phase I and II results

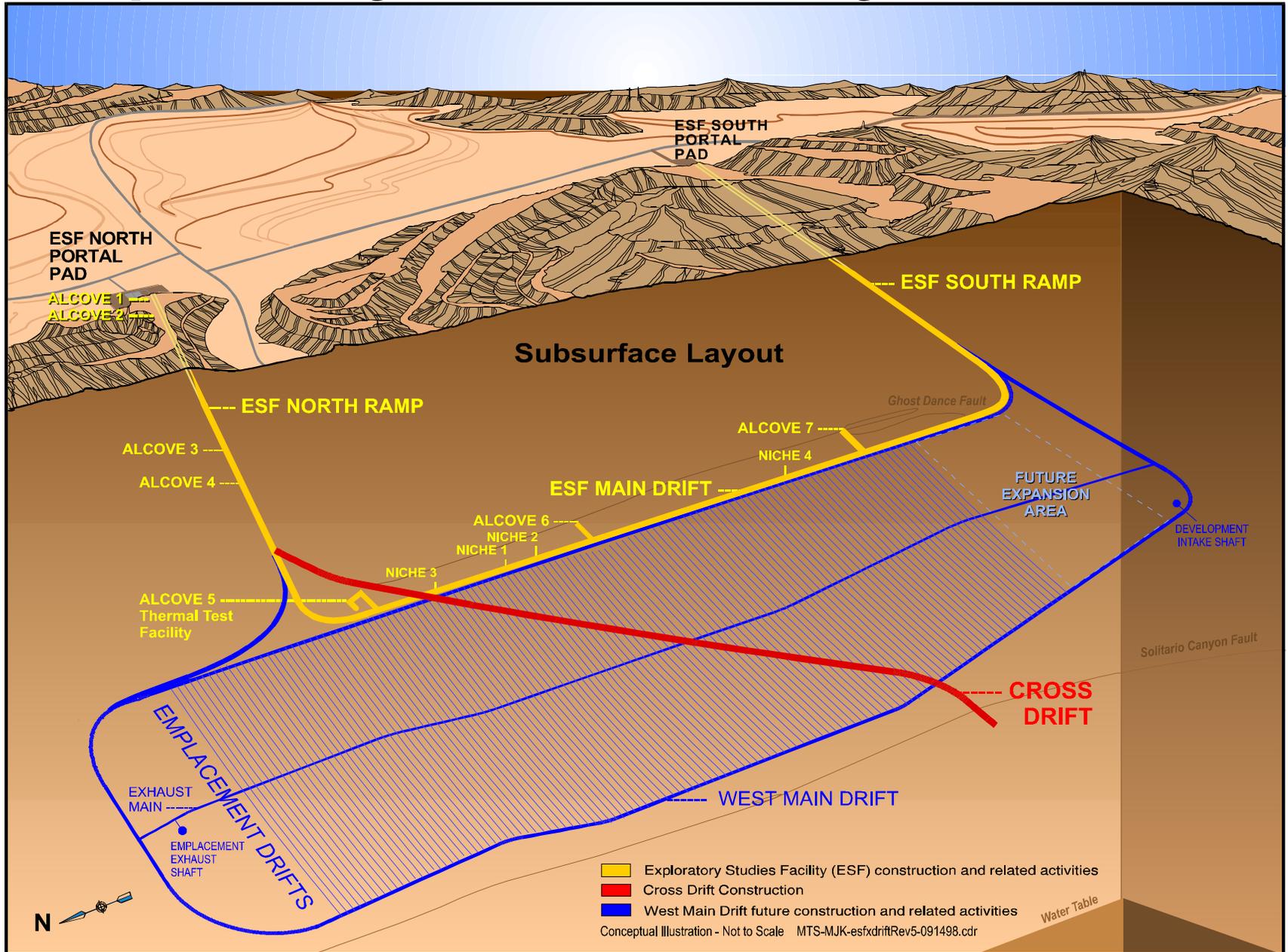
# Overview

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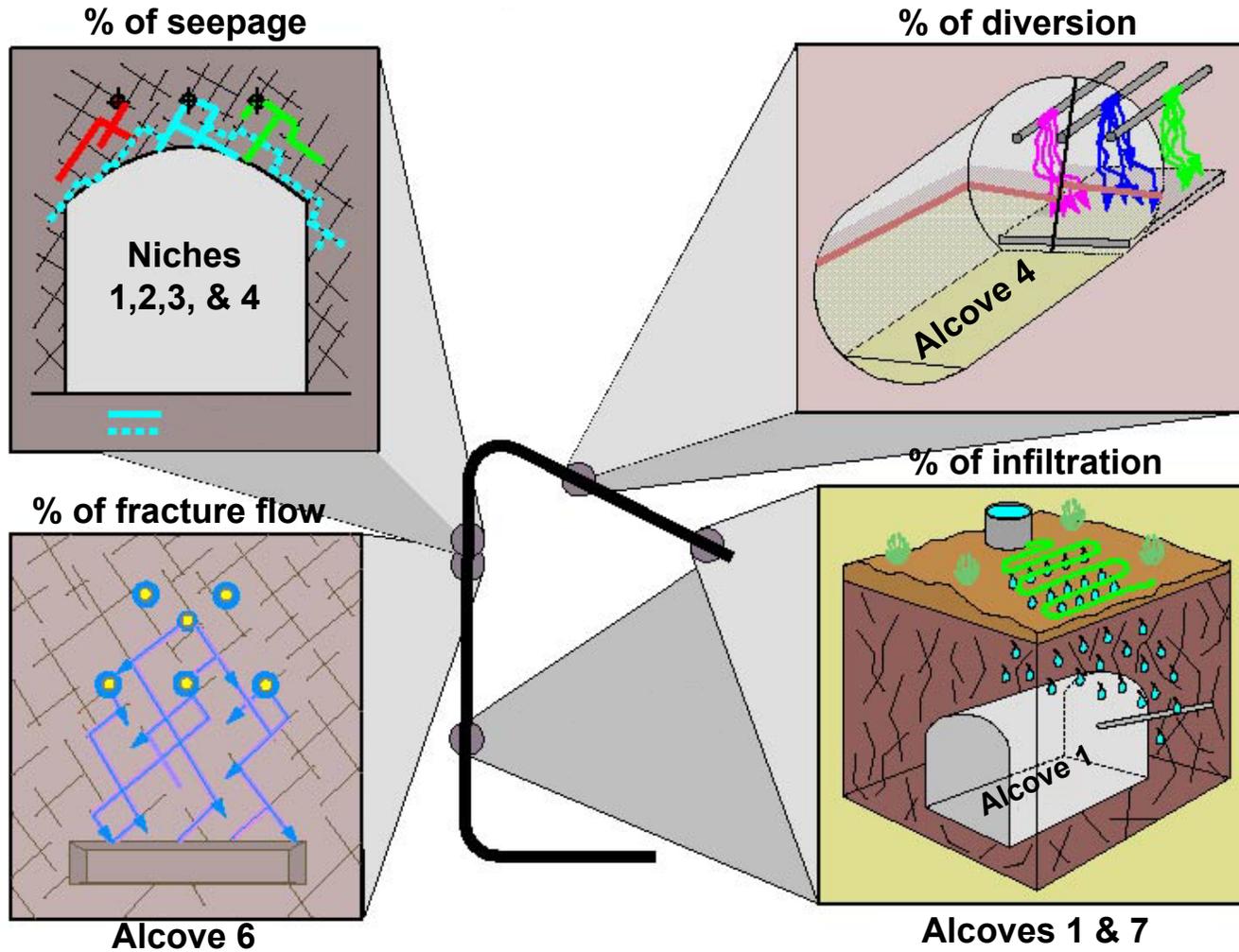
- **C-Well Complex**
  - Prow Pass Testing Results
- **Surface-Based Testing**
  - SD-6
  - WT-24
- **EBS Pilot-Scale Testing**
  - Objectives and Plan

# ESF Testing

# Exploratory Studies Facility and Alcoves

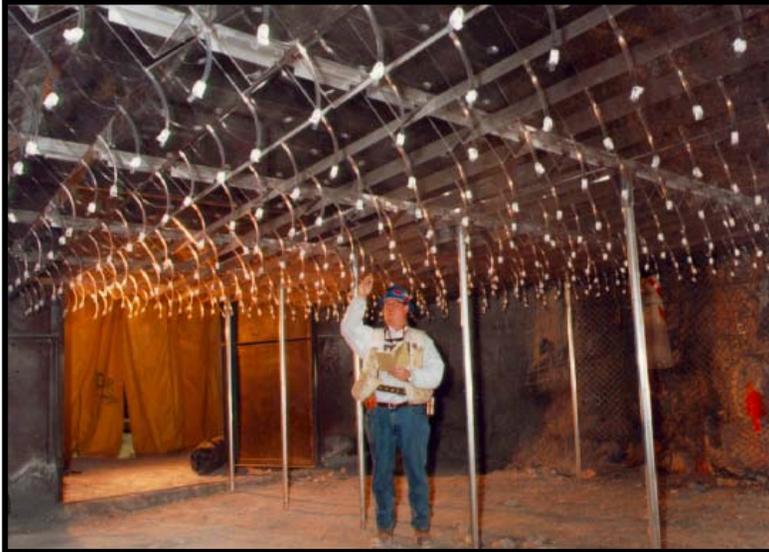


# In Situ Testing in ESF



# ALCOVE 1

## Infiltration & Percolation Study - El Niño Study



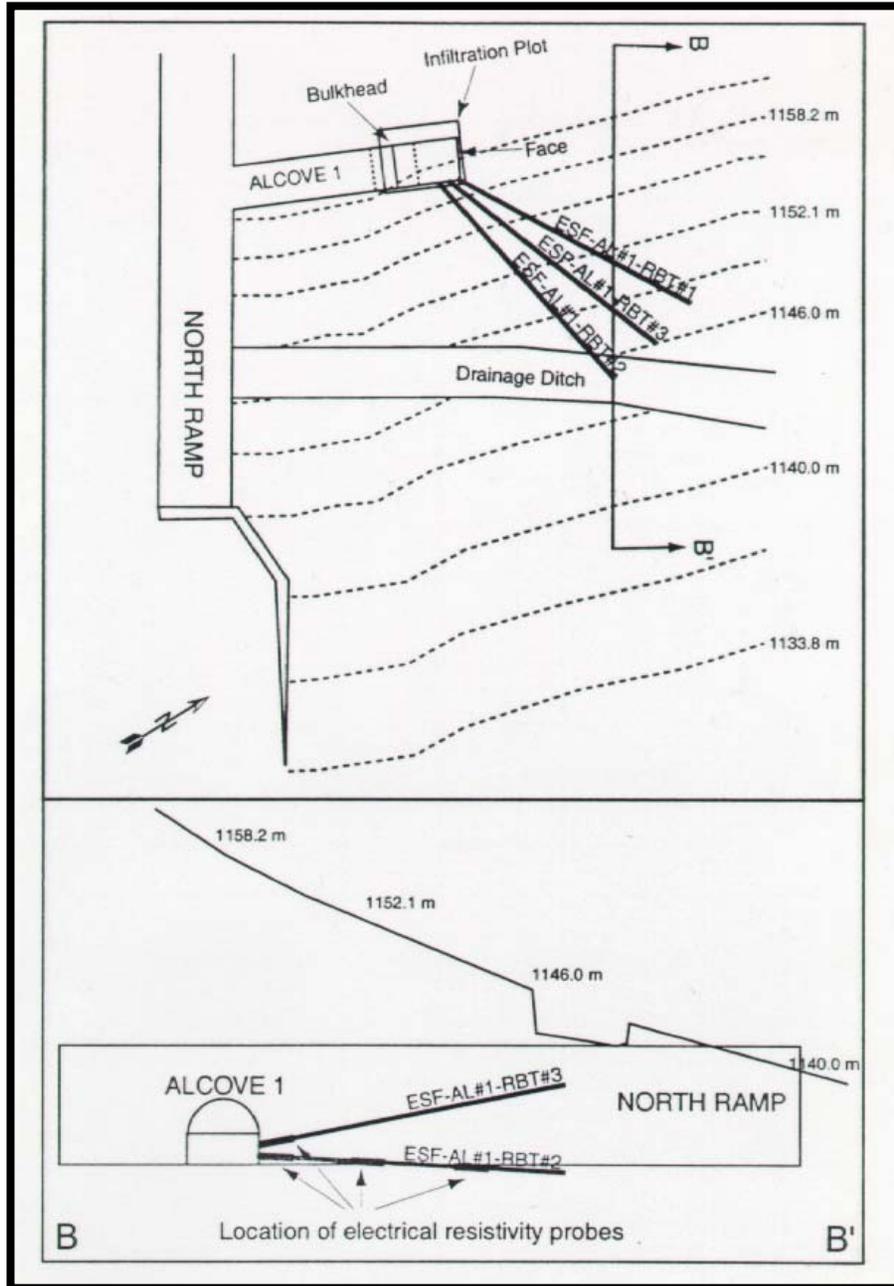
### PURPOSE:

- Monitor the climatic effects associated with an increased rainfall event
- Evaluate the process of surface water infiltration and subsequent percolation through the unsaturated zone above Upper Tiva Canyon Alcove



### FUTURE PLANS:

Continue to conduct infiltration/percolation studies using different aqueous tracers - which monitor percolation of water through the unsaturated zone above Alcove 1



# Alcove 1 Results

- **First Phase**
  - Total volume of water applied was approximately 63,375 gallons
  - Water seepage began after approximately 58 days (after approximately 30,000 gallons applied)
  - Approximately 10% of the applied water was recovered
- **Second phase has begun - plan is to use varying infiltration rates and multiple tracers**

# ALCOVE 4

## Flow Diversion Testing



### PURPOSE:

- To perform small, field-scale unsaturated/seepage test utilizing short boreholes above geologic contact intersected with small near vertical fractures
- A slot excavated under this test bed will be utilized to collect tracers/dyes that are released from the boreholes.

### RESULTS:

- Slot excavation was completed below a test bed with fault and fractures and low permeability tuff layers.
- Air permeability values from packer tests are higher than liquid permeability values from point release tests
- Future tests planned include; flow tests, transport tests, aqueous tracer mixtures, etc.



# **Alcove #6 (Northern Ghost Dance Fault)**

## **Alcove Fracture Matrix Interaction Test**

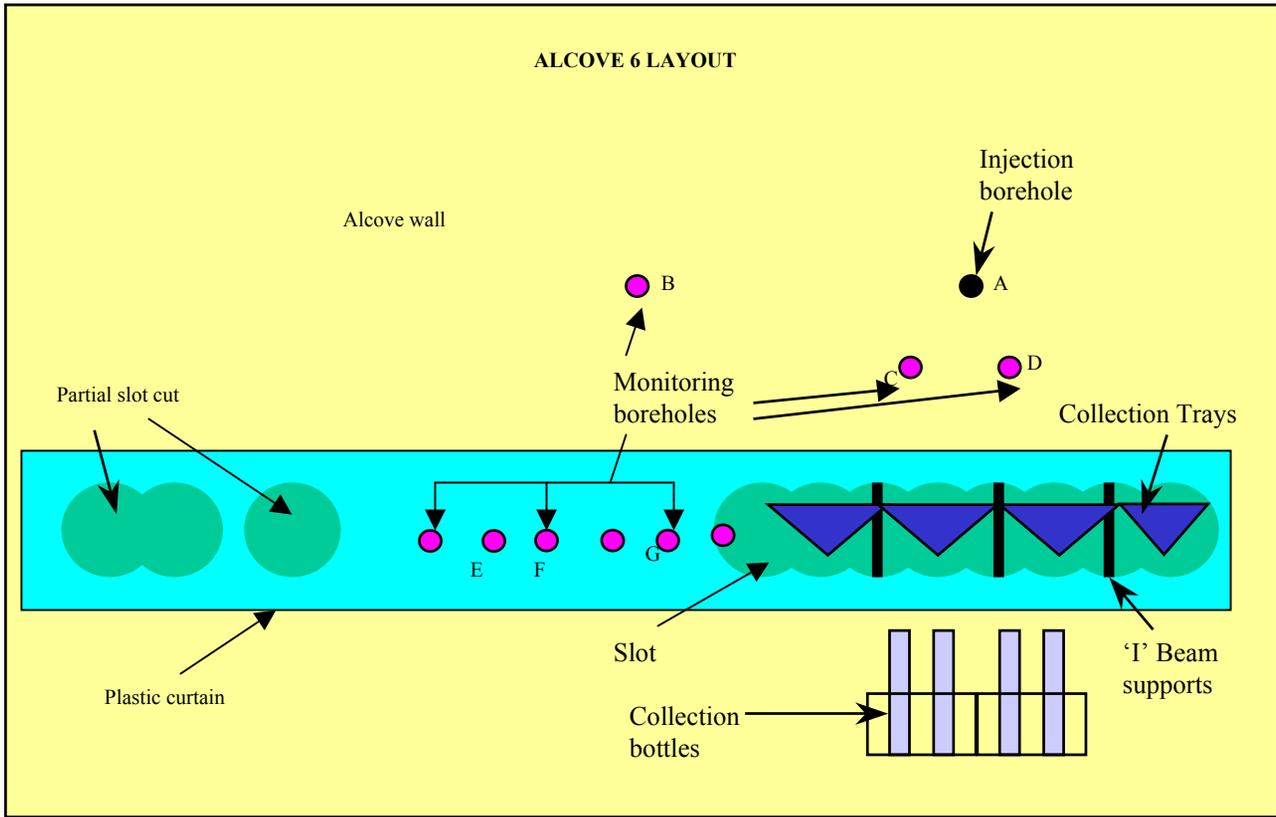
### **Test Objectives:**

- **Provide information regarding percolation and seepage through the potential repository horizon in a fractured area**
- **Drill a series of short boreholes in an area that has a significant amount of fractures**
- **Excavate a slot under the boreholes to allow for collection of the dyes and tracers released into the upper boreholes**

### **Results:**

- **Two liquid injection tests were completed in two test intervals above a slot**
- **For a high permeability zone, 58-70% of injected water volumes flowed through fractures and recovered for tests reaching quasi-steady states**
- **Transient changes were used to estimate fracture volumes**

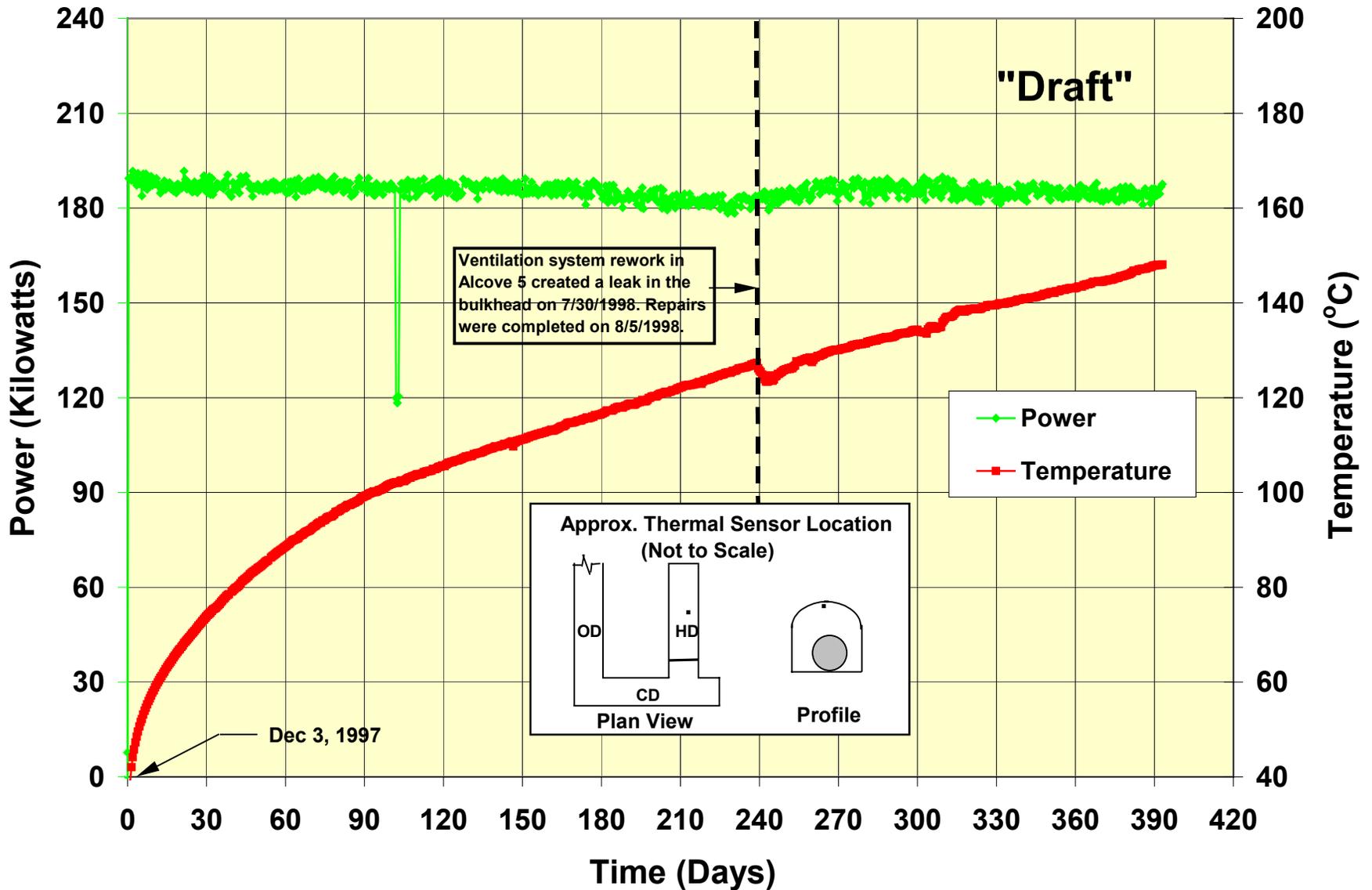
### ALCOVE 6 LAYOUT



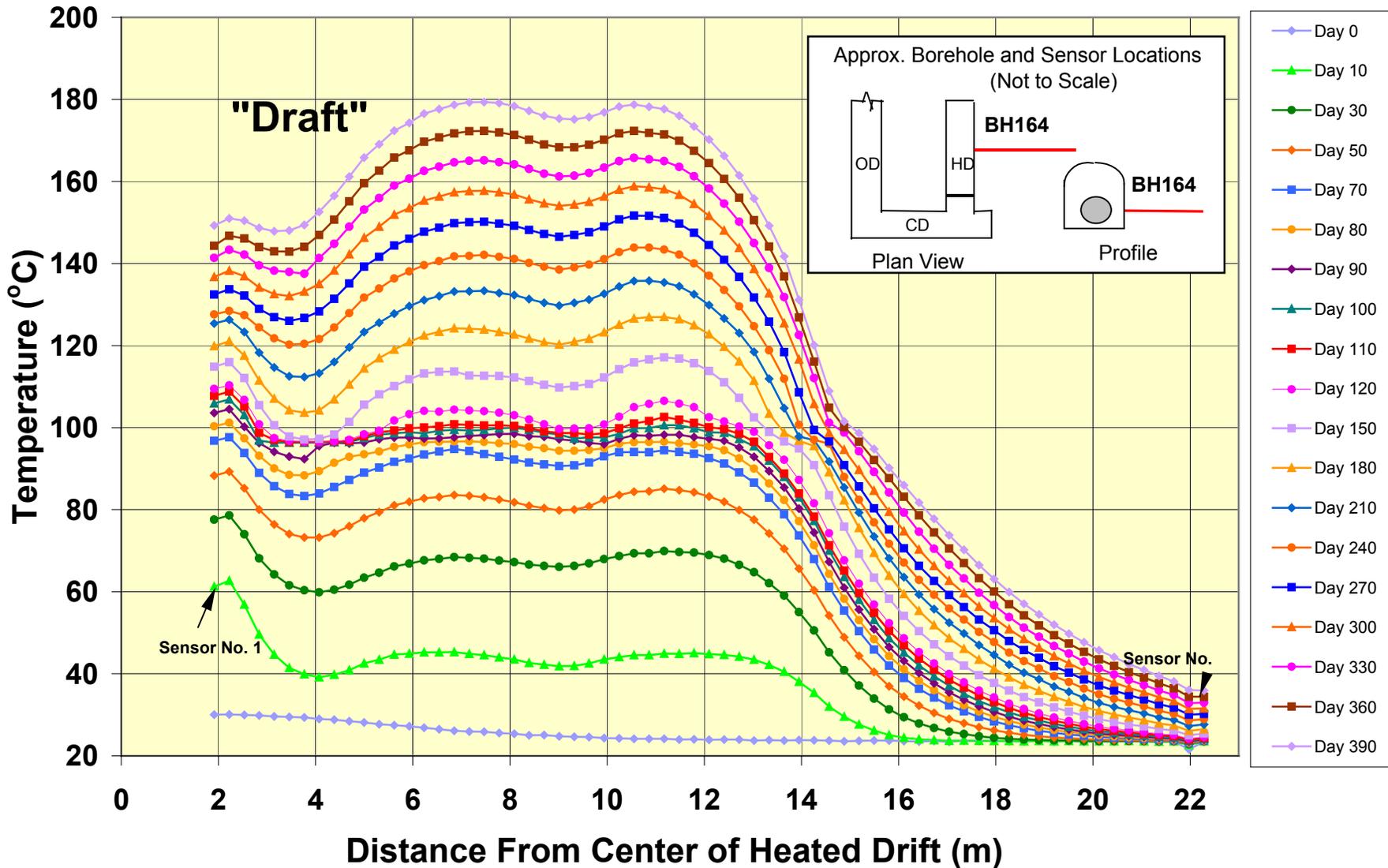
# IN SITU THERMAL TESTING OBJECTIVES

- **Develop a more comprehensive understanding of the coupled T-M-H-C processes in the rock mass surrounding the proposed repository which includes:**
  - **Temperature distribution and heat transfer modes**
  - **Thermal expansion and deformation modulus**
  - **Propagation of the drying and re-wetting regions**
  - **Changes in water chemistry and mineralogy**
- **Two tests are being performed in the ESF to meet these objectives: the Single Heater Test and the Drift Scale Test.**

# Representative Drift-Wall Temperature and Total Power



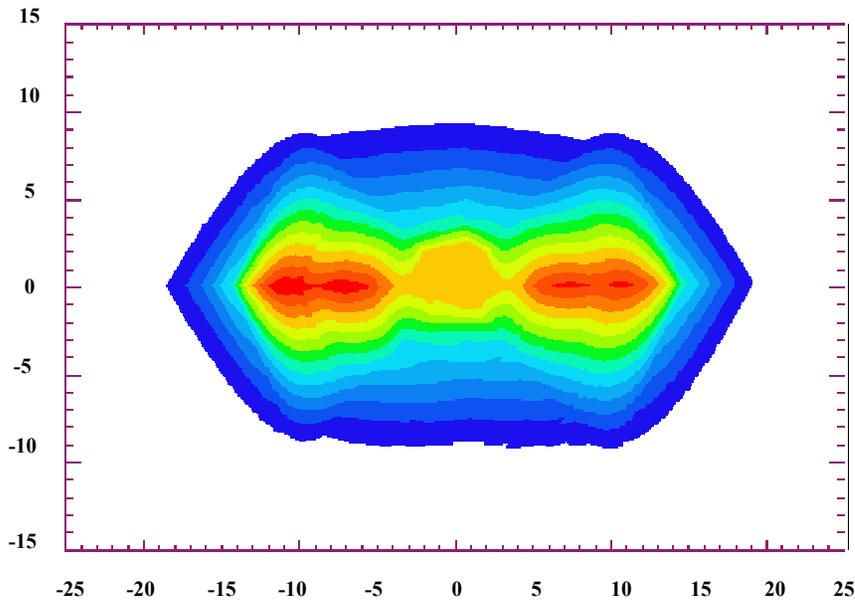
# Parallel to Wing Heater at Midlength of the Heated Drift



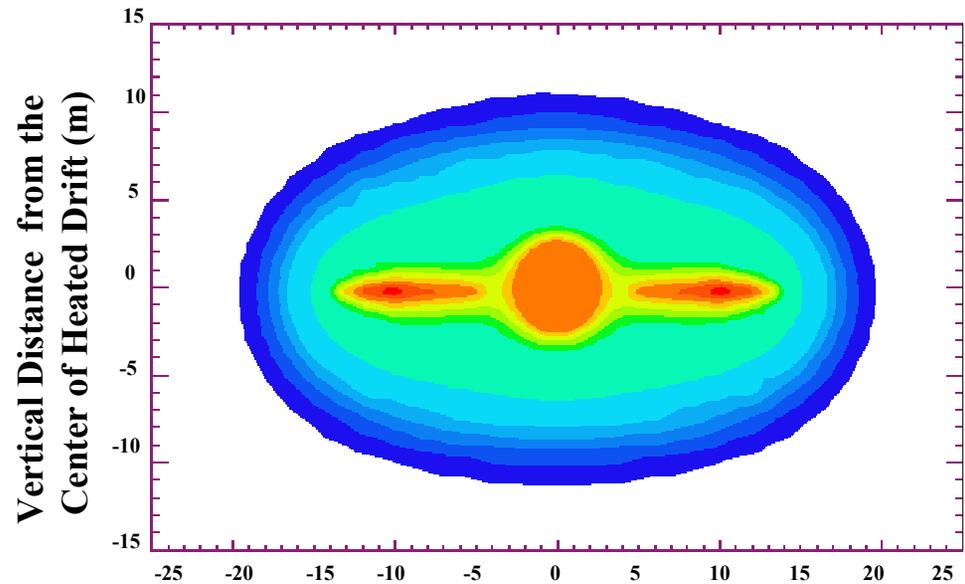
# Thermal Testing: Drift Scale Test

Temperature Contours of Vertical Slice Through  
Mid-Length of Heated Drift at 1 Year.

Measured



Predicted



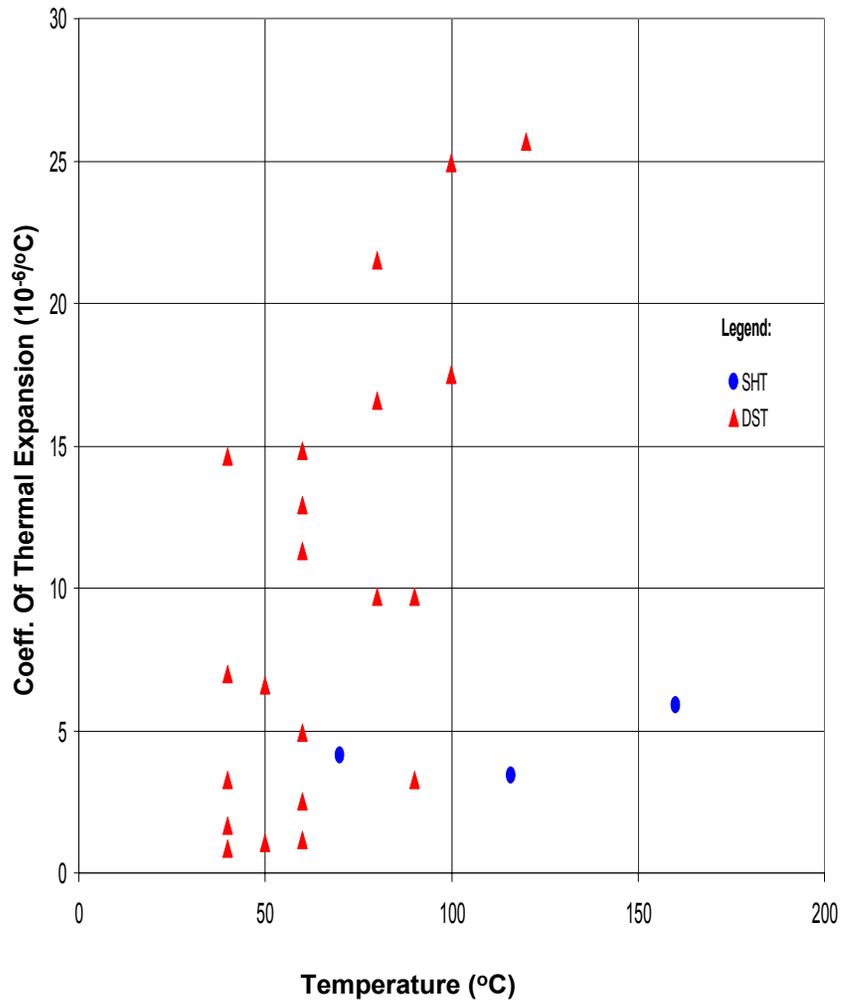
Horizontal Distance from the Center of Heated Drift (m)

Temperature (°C)

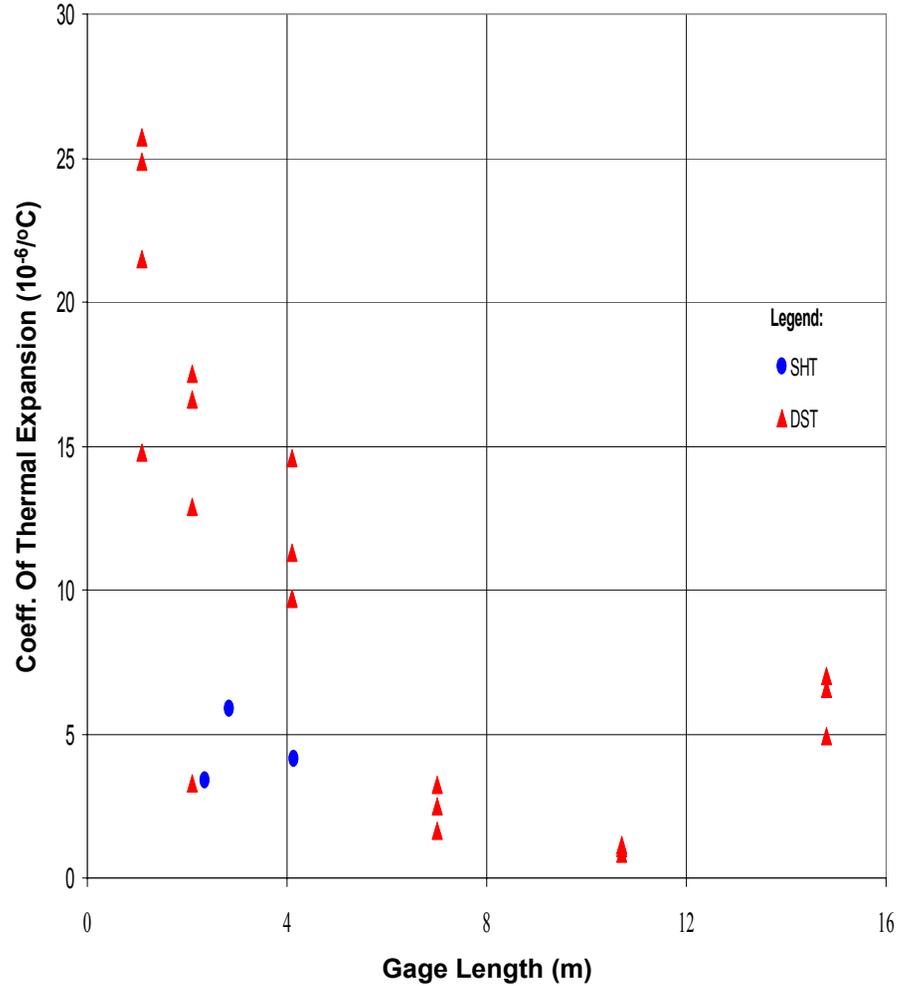


“Draft”

Relationship of Thermal Expansion vs. Temperature



Relationship of Thermal Expansion vs. Gage Length



# Cross Drift

# Lithostratigraphic Predictions and Results

- **Unit Variability**
  - Topopah formational thickness is predictable (predicted within 1.2 meters at SD-6)
  - Topopah subunits are more variable
  - Plus or minus 9 meter thickness change over 150 meters, as documented in boreholes and outcrop
- **Predictions match results very well**

# Lithostratigraphic Predictions and Results

(Continued)

<u>ISM3.0*</u>	<u>Actual</u>	<u>Vertical Difference</u>
Tptpmn 10+78	10+15	6.6 meters
Tptpll 15+21	14+44	8.1 meters
Tptpln 24+10	23+26	14 meters**

\* April 1998

\*\* due to 3 small faults  
totalling >8m offset

# Lithostratigraphic Predictions and Results

(Continued)

- **Geologic Mapping Results**
  - **Three, unexpected faults (< 5 meters offset) mapped in Cross Drift - do not correspond to any known faults at the surface**
  - **Main splay of Solitario Canyon Fault encountered very near predicted location**
    - » **Strike: N18W; Dip: 62SW**
    - » **> 250 meters of vertical offset**
    - » **Footwall (Tptpln) highly-fractured several tens of meters prior to main splay**
    - » **Hanging wall (Tptpul) cut by many smaller faults with minor offset**

# Moisture Monitoring Results

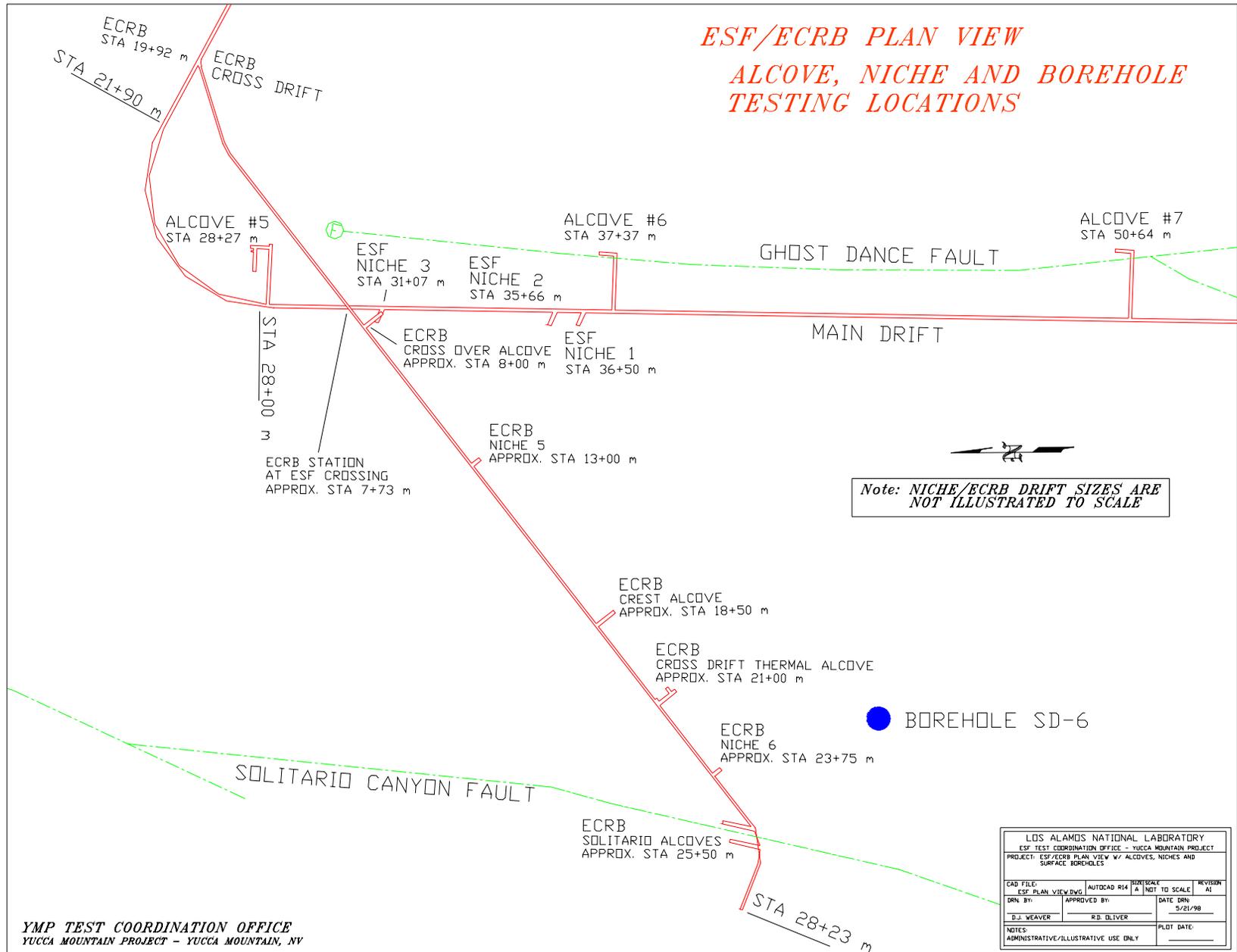
- **51% of the applied construction water moved into fractures**
- **45% of the total evaporation was construction water, with the balance being rock formation water**
- **Construction water has penetrated more than 3 meters from the excavation within the Tptpul, but not as much as observed in the Tptpmn (more than 30 meters)**
- **Overall, there is a net loss of water (on average, drier than pre-construction)**

# Current Plans (FY99)

- **Geologic mapping**
- **Systematic drilling/coring and continued monitoring**
- **Systematic consolidated sampling, including systematic and feature-based samples, for use in hydrologic, hydrochemical, and mineralogic-petrologic-geochronologic studies**

# Current Plans (FY00-FY02)

## ESF/ECRB PLAN VIEW ALCOVE, NICHE AND BOREHOLE TESTING LOCATIONS



LOS ALAMOS NATIONAL LABORATORY			
ESF TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT			
PROJECT: ESF/ECRB PLAN VIEW W/ ALCOVES, NICHEs AND SURFACE BOREHOLES			
CAD FILE:	AUTOCAD R14	PRINTSCALE	REVISION
ESF PLAN VIEW.DWG	A	NOT TO SCALE	A1
DRN. BY:	APPROVED BY:	DATE DRN:	
D.J. WEAVER	R.B. OLIVER	5/21/98	
NOTES:		PLOT DATE:	
ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			

# Current Plans (FY00-FY02)

(Continued)

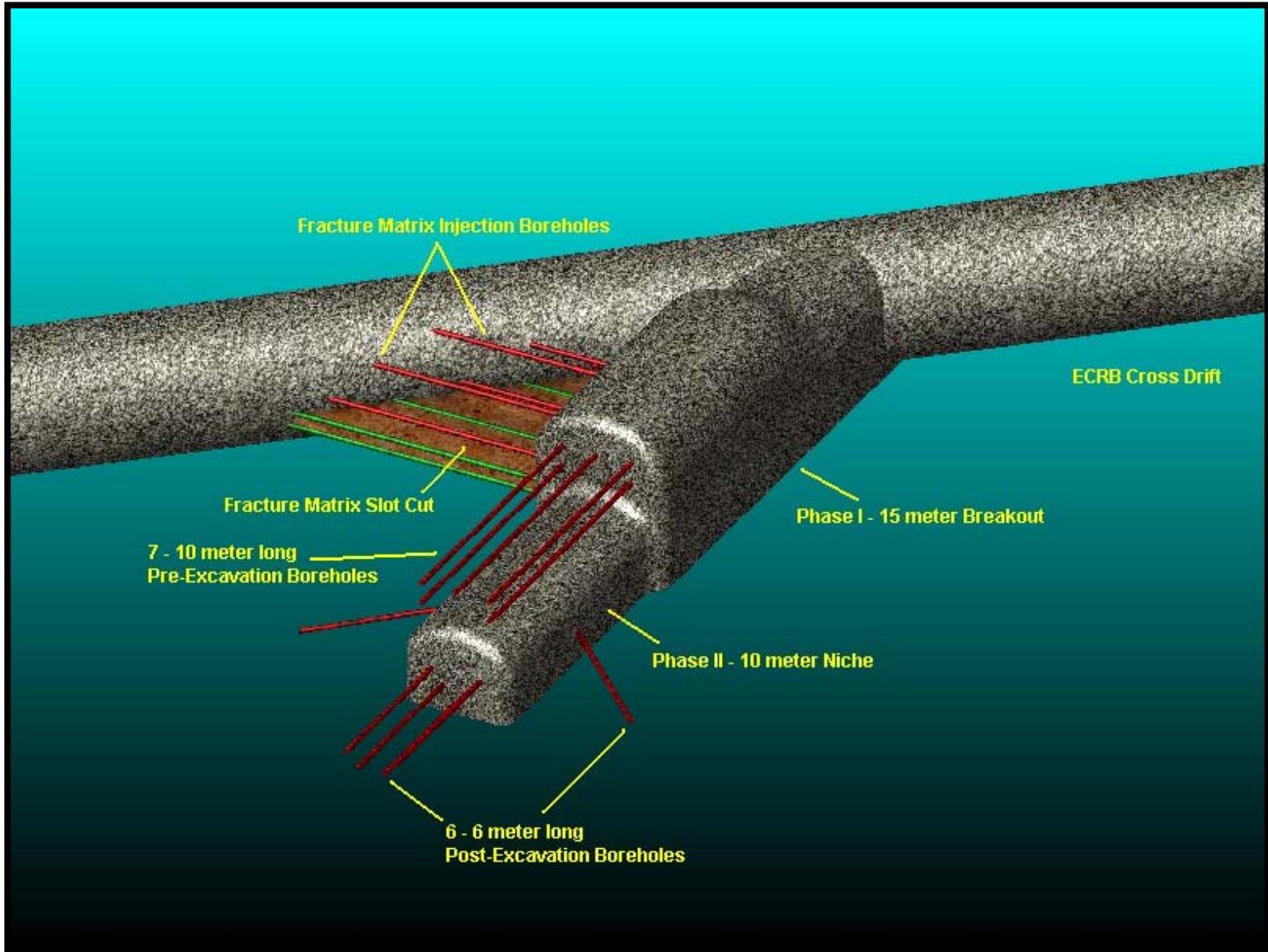
- **A series of alcoves and niches to study flow and seepage and thermal processes**
  - **Niche 5 (Tptpll) - flow, seepage**
  - **Niche 6 (Tptpln) - flow, seepage**
  - **Cross-Over Alcove (Tptpmn) - flow and seepage at larger scale - coupled with ESF Niche 3**

# **Current Plans (FY00-FY02) (cont.)**

- **A series of alcoves and niches to study flow and seepage and thermal processes (cont.)**
  - **Crest Alcove (TptplI) - flow in high infiltration area**
  - **Cross Drift Thermal Alcove (TptplI) - thermally coupled processes, thermomechanical properties, seepage**

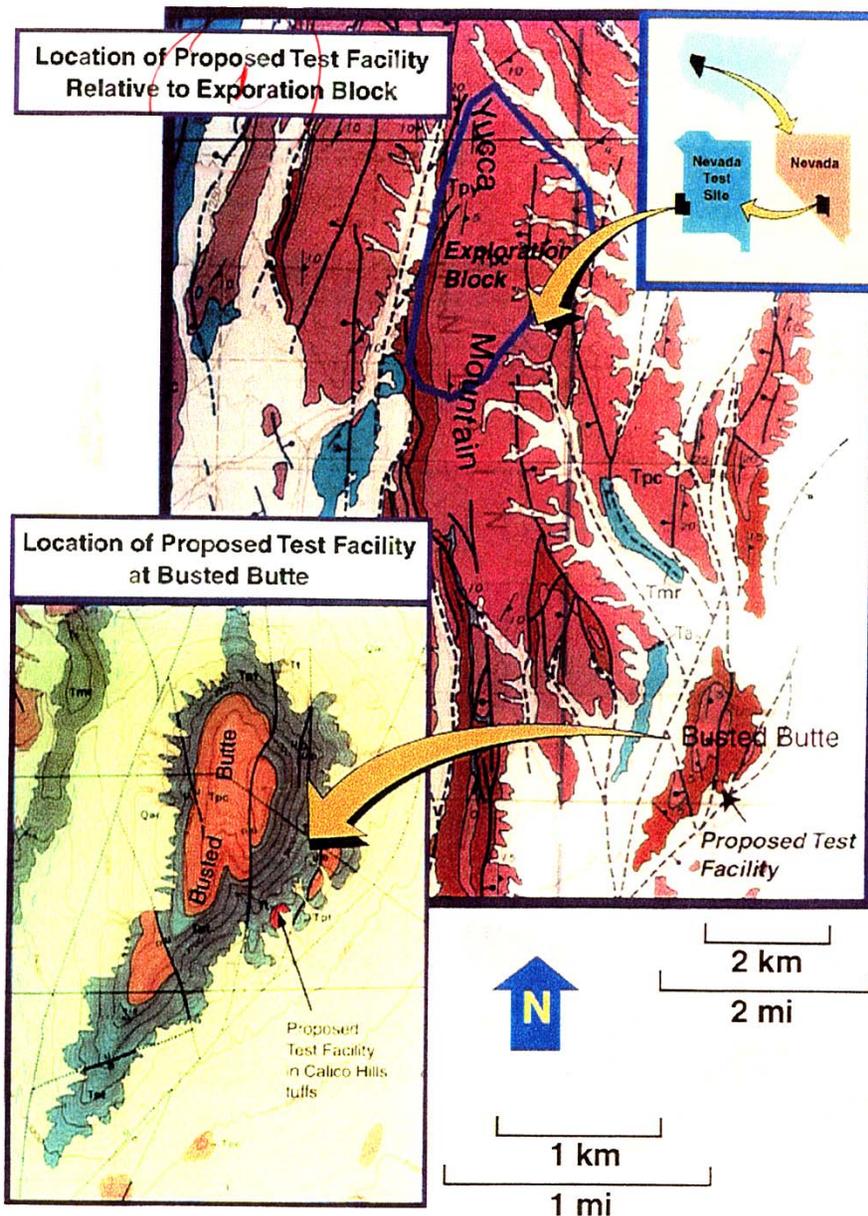
# Current Plans (FY00-FY02)

(Continued)



# **Busted Butte**

# Location Map





# Results

- **Initiation of testing completed for Phases I and II on August 5, 1998**
- **Breakthrough of fluorescein tracer in Phase Ib occurred on June 16, 1998 at a rate of 30 cm in 30 days**
- **Tracer injection for Phase IIb (10 ml/hr/injection point) - located in the CHn in the lower part of the test block**
  - **Initiated on July 30, 1998 and breakthrough on August 6, 1998 (holes 46 and 48) and September 1, 1998 (hole 9)**

# Results

(Continued)

- **Tracer injection for Phase IIc (50 ml/hr/injection point) - located in the Tpv2 in the upper part of the test block**
  - Initiated on August 5, 1998 and breakthrough on October 20, 1998 (hole 16) and November 11, 1998 (hole 17)
- **Tracer injection for Phase IIa (1 ml/hr/injection point) - located in the Tpv2 in the upper part of the test block**
  - Initiated on July 23, 1998 and no breakthrough to date

# Results

(Continued)

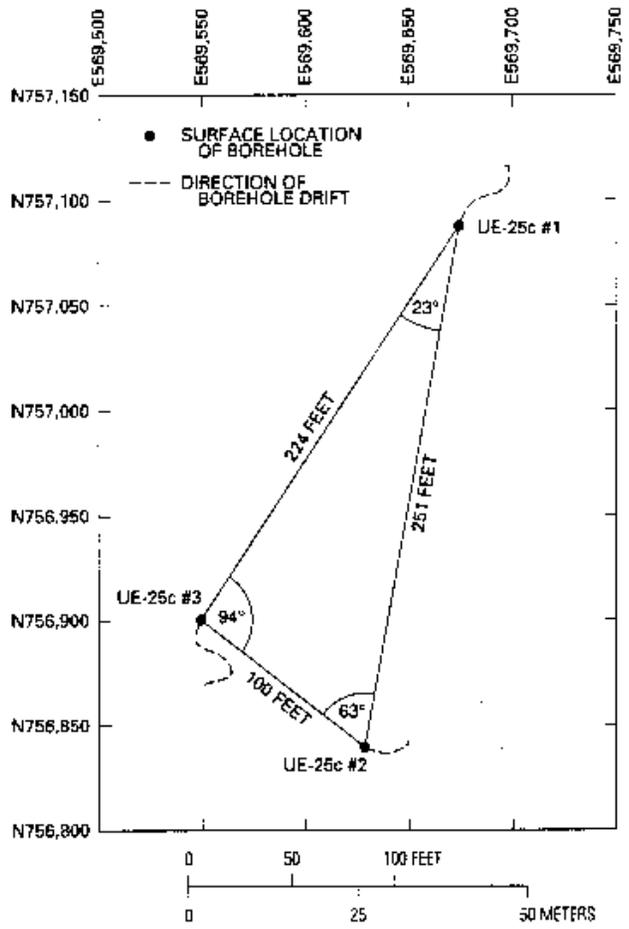
- **Mineback of Phase Ia is in progress**
- **Overcoring of Phase Ib boreholes is complete**
  - **Observations on the ingress of fluorescent tracer into the fractured rock mass are consistent with breakthrough data obtained from collection pads over the past six months**

# Results

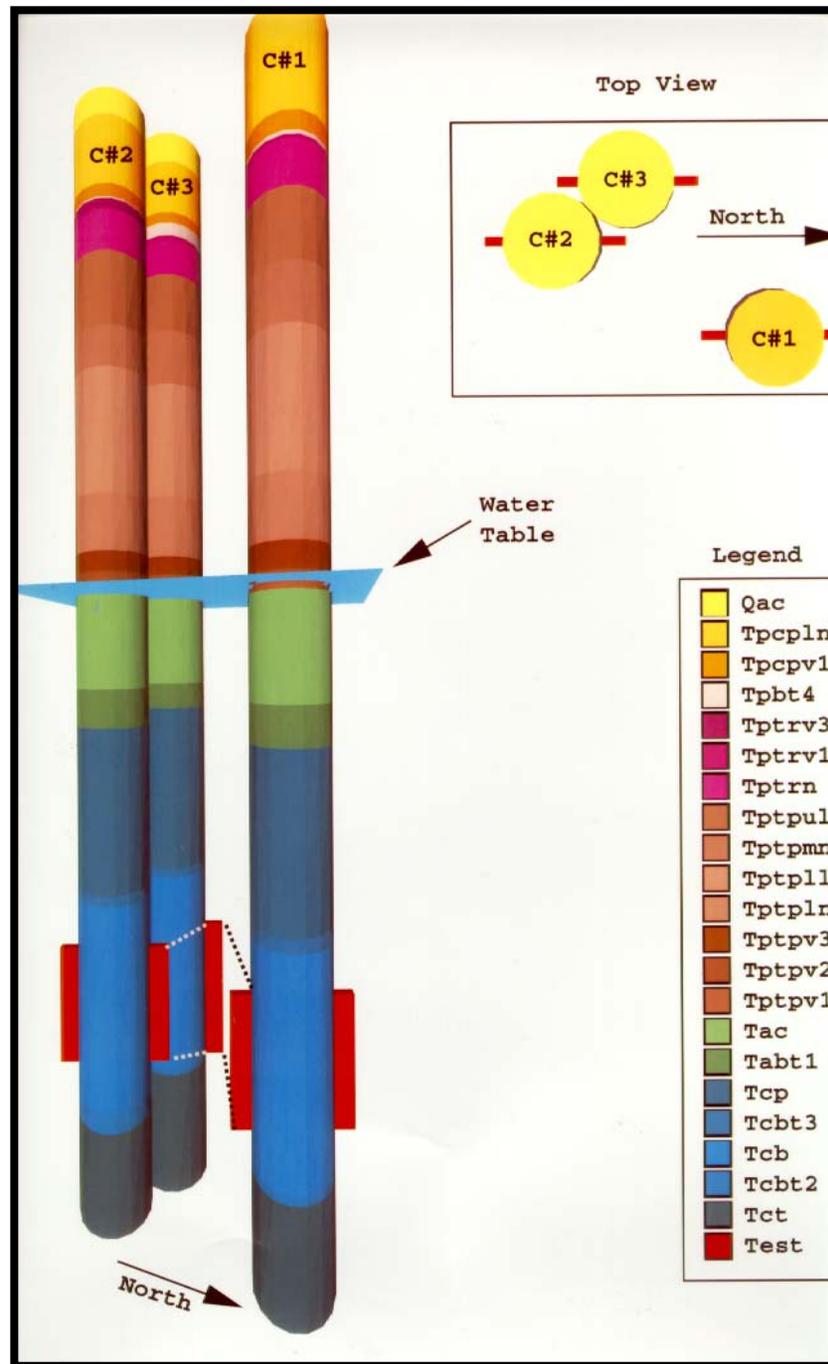
(Continued)

- **Implications for UZ Flow and Transport**
  - **Providing important insights into the behavior of fracture-matrix interactions in and immediately above the Calico Hills formation**
  - **Fracture flow does not occur in these lithologies unless accompanied by substantial matrix flow**
  - **Important consequences for transport in the unsaturated zone beneath the potential repository horizon as significant additional sorption of radionuclides is expected**
  - **Future work involves quantifying the fracture-matrix coupling term so that it can be incorporated into site-scale models for TSPA-LA**

# C-Well Complex



Surface location of C-holes, referenced to Nevada Zone 2 coordinates



# Hydraulic Tests in Prow Pass Tuff

- **Hydraulic test conducted in the Prow Pass (PP) interval 6/2-6/11/98:**
  - **c#2 pumped at 5.2 gpm**
  - **c#1, c#3, and ONC#1 observation wells: 94-2,870 ft from pumping well**
  - **PP 184-238 ft thick in C-holes (62-104 ft of transmissive zones); not fully penetrated in ONC#1**
  - **Drawdown in c#2 443 ft (99% from well losses); 1.8 ft in c#3, 0.4 ft in c#1, 0.04 ft in ONC#1**
  - **Analysis yields transmissivity of 400ft<sup>2</sup>/day and storativity of 0.001 between C-wells and ONC#1**
  - **PP test results are applicable to low-permeability tuffs at Yucca Mountain, whereas lower bullfrog results are applicable to high-permeability tuffs**

# Conservative Tracer Tests in the Prow Pass

- **Forced gradient, partial recirculation test**
  - **Injected iodide and TFBA into c#3 while pumping c#2 at 5.2 gpm - recirculated 1.5 gpm into c#3**
  - **Longitudinal dispersivity (measure of medium's ability to disperse a solution along flow direction ranges from 0.9 to 4.5 feet**
  - **Transverse dispersivity (measure of medium's ability to disperse a solution perpendicular to flow direction), cannot be obtained from forced-gradient tests**

# **C-Wells Reactive Tracer Testing in Prow Pass Tuff**

- **Pumping from Prow Pass Tuff in c#2 at ~5 gpm**
- **Recirculation of ~1.5 gpm (30% of Production) into c#3**
- **Fluorescent polystyrene microspheres injected into c#3 at ~1.5 gpm on 9/23/98**
  - **640-nm diameter blue-dyed spheres**
  - **280-nm diameter orange-dyed spheres**

# **C-Wells Reactive Tracer Testing in Prow Pass Tuff**

(Continued)

- **Solutes and one additional microsphere injected into c#3 at ~1.5 gpm on 9/25/98**
  - **Pentafluorobenzoic Acid (PFBA) - nonsorbing, small diffusion coefficient**
  - **Chloride, Bromide - nonsorbing, larger diffusion coefficients**
  - **Lithium - sorbing, intermediate diffusion coefficient**
  - **280-nm diameter yellow-dyed spheres**

# **C-Wells Reactive Tracer Testing in Prow Pass Tuff**

(Continued)

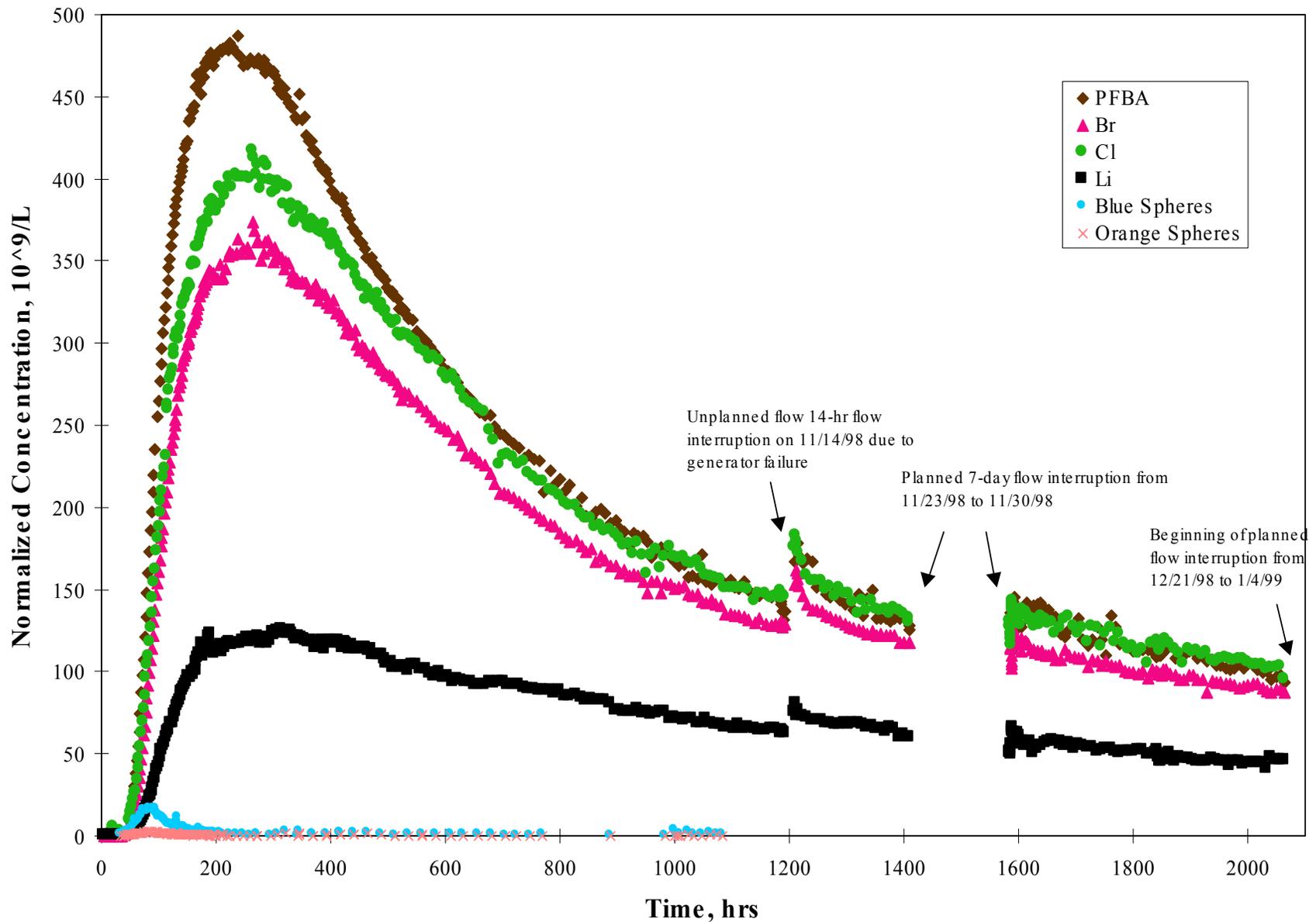
- **Solute recoveries through 12/20/98 range from 46% (PFBA) to 16% (lithium)**
- **Matrix Diffusion is evident from differences in normalized responses of nonsorbing solutes and from “rebounds” in solute concentrations after flow interruptions**
- **Lithium attenuation is consistent with dual-porosity concept of SZ**

# **C-Wells Reactive Tracer Testing in Prow Pass Tuff**

**(Continued)**

- Lithium sorption is slightly greater than observed in laboratory tests, suggesting that laboratory tests will yield conservative transport parameters for field-scale reactive transport**
- Microspheres are highly attenuated relative to solutes; attenuation much greater than in previous Bullfrog Tuff tracer test (Bullfrog Tuff has higher conductivity than Prow Pass Tuff at the C-wells)**

# C-Wells Reactive Tracer Test Results: Normalized Tracer Concentrations



# **Surface-Based Testing**

# Surface-Based Testing

- **SD-6**

- **Current depth is 2541 feet, but drilling difficulties encountered**
- **Planned depth is 2850 feet**
- **Original objectives met:**
  - » **Planned core obtained**
  - » **Mineralogy and <sup>36</sup>Cl samples obtained**
  - » **Critical Stratigraphy obtained for Design**
  - » **Logging complete to 2540 feet**
- **Original objectives not yet met:**
  - » **No water samples from regional aquifer**
  - » **Water table encountered, but not accessible for measurement**
  - » **No logging below water table**
  - » **Aquifer pumping test not conducted**
- **Plan in place to complete borehole to meet all original objectives**

# Surface-Based Testing

(Continued)

- **WT-24**
  - Borehole complete to planned depth
  - Borehole at total depth in relatively tight portion of regional aquifer so no pump testing conducted
  - Demobilizing equipment

# **EBS Pilot-Scale Testing**

# Objectives and Plan

- **Tests being conducted at DOE facility in North Las Vegas**
- **Demonstrate performance of various EBS concepts at the field-scale (quarter-scale to current design of drift/waste package) at ambient and elevated temperatures**
- **Infiltration rates range from present-day to superpluvial values**
- **Focus is on monitoring water movement through the EBS materials using instrumentation and fluorescein tracer**

# Objectives and Plan

(Continued)

- **Post-test characterization involves removal of materials and observing path of traced water**
- **Test canister #1 initiated in mid-December, 1998**
  - **EBS concept is Richard's barrier (medium sand over coarse sand) at ambient temperatures under superpluvial rates**

# Objectives and Plan

(Continued)

- **Test canister #2 initiated in mid-January, 1999**
  - **EBS concept is coarse sand backfill at ambient temperatures under superpluvial rates**
- **Test canister #3 planned for initiation in late February, 1999**
  - **EBS concept is Richard's barrier (fine sand over coarse sand) with similar configuration to Test Canister #1**

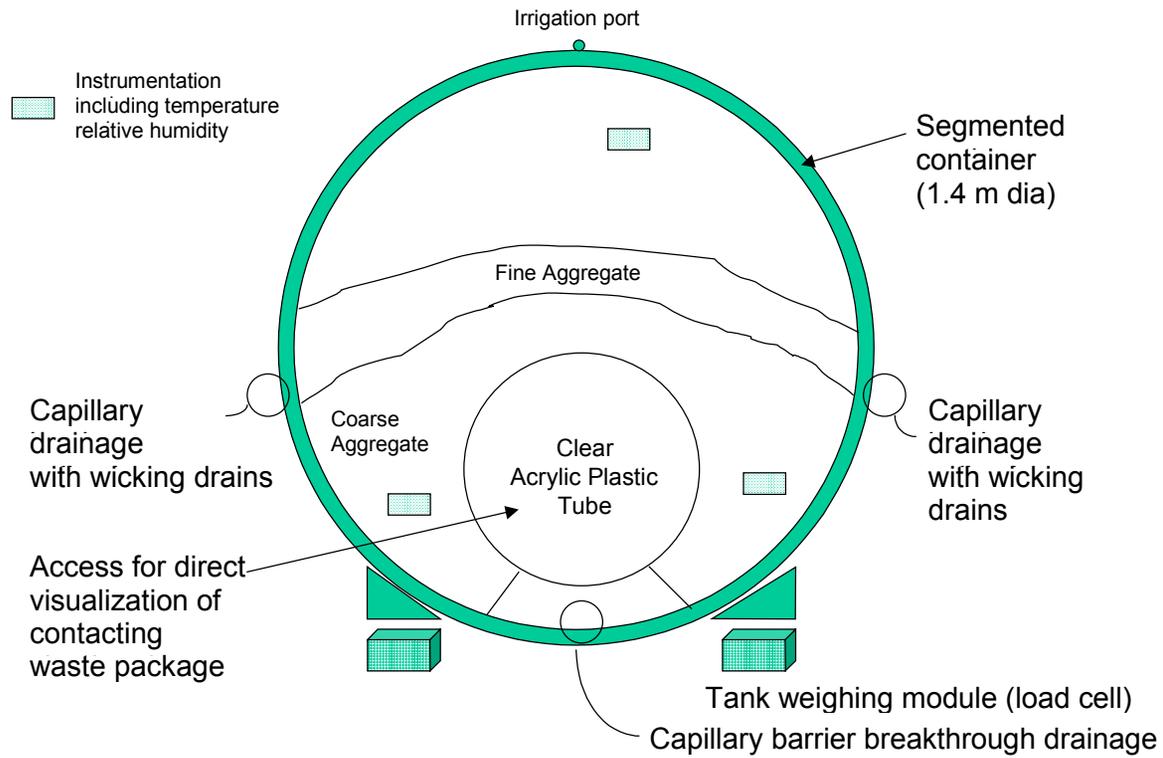


Figure 1-1 cross-section view of ambient capillary barrier 1/4 scale