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Yucca Mountain Site Characterization Office
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ACCELERATED SURFACE-BASED TESTING PLAN FOR AMBIENT PNEUMATIC CONDITIONS (SCPB: 8.3.1.2.2.3, 8.3.1.2.2.6, 8.3.1.2.2.7)

The following discussion addresses the major questions described in your June 21, 1994, letters to Dwight E. Shelor regarding the State of Nevada concerns on pneumatic pathways and the staff evaluation of open item responses on dewatering and air movement in the exploratory studies facility.

The accelerated surface-based testing plan, first presented at the August 1994 Technical Project Officers meeting by Robert Craig of the U.S. Geological Survey (USGS), and at the Nuclear Waste Technical Review Board full board meeting October 19-20, 1993 (enclosure 1), does not represent a change in testing strategy, but a logistical change to accommodate implementation of the tunnel boring machine (TBM). This plan was developed to address the concern that the U.S. Department of Energy (DOE) would miss an opportunity to characterize undisturbed pneumatic conditions if a long-term monitoring program was not implemented prior to start-up of the TBM and subsequent excavation of the North Ramp. Since this reflects only a logistical change, the various activities remain as described and documented in approved Study Plans 8.3.1.2.2.3 (Characterization of the Percolation in the Unsaturated Zone, Surface-Based Study), 8.3.1.2.2.6 (Characterization of the Yucca Mountain Unsaturated-Zone Gaseous-Phase Movement), and 8.3.1.2.2.7 (Hydrochemical Characterization of the Unsaturated Zone).

Since initial preparation of these study plans, experience has been gained through prototype testing and data collection under approved quality assurance plans for all components of the program. Experience to date in obtaining similar data includes:

1. USW UZ-1, instrumentation and gas sampling.

2. G-tunnel, development of instrument methods.

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3. Hydrologic Research Facility auger holes, demonstration of instrumentation methods.

4. USW UZ-6/6s, ongoing study to determine topographic and barometric effects.

5. Apache Leap, air-permeability prototype testing with packer systems.

6. C-well complex, air-permeability prototype tests.

7. USW UZ-16, gaseous-phase measurements and sampling/air-permeability measurements.

The experience gained so far in the program demonstrates the capability to perform complex downhole testing, which is why the program could be accelerated to accommodate the TBM schedule. The current program, based on a TBM test-phase start-up date of August 8, 1994, is shown on Enclosure 2. The most important point which is addressed is the timing of hole stemming along the North Ramp and the main drift. The TBM is scheduled to reach a location near NRG-5 in early March 1995. NRG-6 and NRG-7a will be stemmed prior to December 1994. This will give the program one full winter season of monitoring to determine baseline conditions. The next area of opportunity is along the southern part of the main drift where USW UZ-7, USW UZ-7a, USW SD-12, and USW SD-7 will be stemmed one winter season prior to the TBM reaching the location of USW SD-12 in early March of 1996. These holes will be stemmed by late November 1995 and will provide the baseline measurements necessary to determine impacts of the TBM excavation on the gaseous flow system. By this time, we will have two years of data from the holes located along the North Ramp which DOE believes will provide an adequate record for comparing pneumatic changes, if any, to the monitoring system to the south. The long-term monitoring program will continue through licensing, and possibly through performance confirmation.

The details of the instrumentation and the individual tests are given in the study plans identified above. Prior to stemming for long-term monitoring, the individual tests are conducted systematically as shown in Enclosure 3. The time periods given for each phase are approximate, and really depend upon hole conditions and the primary targets of interest as defined by geologic logs and visual information obtained through the downhole camera. One function of the air-permeability testing is to determine optimum locations for placement of the permanent sensors for the long-term monitoring program. See Enclosure 1 for a generalized description of the borehole test configurations.

USW UZ-1 has been stemmed for long-term monitoring. Monitoring in USW UZ-6/6s began in late 1985 and provides the longest data record for pneumatic processes that is available for Yucca Mountain, Nevada. The plan for the entire surface-based testing program is shown on Enclosure 4. DOE believes that the coverage provided through a combination of different tests, some over several seasons, will provide adequate information to calibrate the gaseous phase submodel of the unsaturated zone site-scale model as described in Study Plan 8.3.1.2.2.9 (Site Unsaturated Zone Modeling and Synthesis).

Initial gas-phase chemistry has been completed for NRG-6 and NRG-7. Currently, air-permeability measurements are being made in NRG-7a. When this is completed, the air-permeability unit will move to NRG-6 and conduct similar tests. After completion of these tests, both holes will be stemmed according to the design as shown in the Study Plan 8.3.1.2.2.3 (Characterization of the Percolation in the Unsaturated Zone, Surface Based Study). The schedule for stemming these holes does not leave any room for slippage, and major planning efforts have been made to ensure the success of this program. All downhole sensors have excellent precision and accuracy as described in several 1994 High-Level Waste Conference papers:

1. "A Borehole Instrumentation Program for Characterization of Unsaturated-Zone Percolation," by J. Kume and J. P. Rousseau.

2. "Results of Prototype Borehole Instrumentation at the Hydrologic Research Facility, Area 25, Nevada Test Site," by J. P. Rousseau, M. A. Kurzmack, and A. Greengard.

3. "Evaluation of a 6-Wire Thermocouple Psychrometer for Determination of In-Situ Water Potentials," by C. L. Loskot, J. P. Rousseau, and M. A. Kurzmack.

Prior to any attempt for permanent installation, a grout test will be conducted in USW UZ-16. This grout test will serve as a dry run for the permanent installations. Additionally, both NRG-6 and NRG-7a will be reamed to a larger diameter, 8-3/4 inches, to ensure proper placement of the sensors. The current schedule will have NRG-7a stemmed by the end of October 1994 and NRG-6 stemmed by the end of November. This schedule could slip by several weeks depending on the completion of the grout test in UZ-16. However, the project is confident that the holes will be stemmed properly, and in time to collect pneumatic data for one complete winter cycle prior to any impact on gaseous flow through excavation of the North Ramp.

The data collection phase as previously described provides the necessary parameters to calibrate and run the unsaturated-zone site-scale model as described in Study Plan 8.3.1.2.2.9 (Site Unsaturated-Zone Modeling and Synthesis). The model is continuously being improved through the efforts of Lawrence Berkeley Laboratory (LBL) and the USGS. This model is being used to examine moisture, heat, and gas flow estimates within the mountain, predict thermodynamic conditions in the Exploratory Studies Facility (ESF) and new boreholes, and assist in repository design and performance assessment. LBL (Gudmundur S. Bodvarsson) has made considerable progress with the model. Simulations of one-, two- and three-dimensional moisture flow have been conducted; the gas component and geothermal gradient have been incorporated into the three-dimensional site scale model; the numerical grid for the ESF is being completed to be able to simulate pneumatic changes along the North Ramp. Future efforts include development of a submodel to simulate pneumatic processes in the vicinity of USW UZ-6/6s, and predrilling predictions of thermodynamic conditions in boreholes.

Concern was raised about potential changes in pore water chemistry as a result of ESF construction which could impact determination of baseline hydrochemistry. Cores have already been collected from NRG-4, NRG-5, NRG-6, and NRG-7a for water extractions. Therefore, this concern will be addressed since pore water chemistries from the cores taken from the vertical boreholes will be compared to those taken in the alcoves within the ESF. The plan, as discussed herein, addresses the collection of all the hydrologic parameters as described in the Site Characterization Plan, Volume IV, Part B, Table 8.3.1.2-1, pages 8.3.1.2-13 to 8.3.1.2-19. In the final analysis, the program that has been put into place is adequate to define ambient, gaseous flow within Yucca Mountain prior to ESF excavation.

If you have any questions, please call either Joseph J. DLugosz, representing the Assistant Manager for Scientific Programs, at (702) 794-5102 or Thomas W. Bjerstedt, representing my office, at (702) 794-7590.

For Stephan J. Brocoum
Assistant Manager for
Suitability and Licensing

AMSL:TWB-4499

Enclosures:
1. R. W. Craig Presentation
2. ESF Locations and Schedule
3. Surface-Based Testing Procedures
4. Surface-Based Testing Program

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U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: ACCELERATED SURFACE-BASED TESTING TO PROVIDE INFORMATION ON THE UNDISTURBED SITE AHEAD OF ESF CONSTRUCTION

PRESENTER: ROBERT W. CRAIG

PRESENTER'S TITLE AND ORGANIZATION: DEPUTY TECHNICAL PROJECT MANAGER
U.S. GEOLOGICAL SURVEY
LAS VEGAS, NEVADA

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LAS VEGAS, NEVADA
OCTOBER 19-20, 1993

ENCLOSURE 1

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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

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Objectives

- Obtain data before ESF construction
- Monitor effects of ESF construction on baseline conditions
- Assess impacts of ESF construction on site conditions

Data Collection Covered Primarily by Three Study Plans

Study 8.3.1.2.2.3

- Characterization of the percolation in the Unsaturated Zone; surface-based study

- Determine the *in situ* bulk-permeability and bulk-hydraulic properties of the unsaturated media

- Evaluate *in situ* distribution of potential energy and the pneumatic and hydraulic properties of the conducting rock

Data Collection Covered Primarily by Three Study Plans

(Continued)

Study 8.3.1.2.2.6

- Characterization of the Yucca Mountain unsaturated-zone gaseous-phase movement

- Determine, the near-field air conductivities, storativity, and anisotrophy of units by flow, pressure, and gas-composition measurements

- Monitoring of gaseous circulation with time, and flow profiles with depth, should provide data that can be used to determine bulk pneumatic conductivity by model calibration

Data Collection Covered Primarily by Three Study Plans

(Continued)

Study 8.3.1.2.2.7

- Hydrochemical characterization of the unsaturated zone
- Understand the gas-transport mechanism and provide evidence of gas-flow direction, flux, and travel time within the unsaturated zone
- Evaluate the effects of air introduced to the system (natural or man-made) so that the study can provide valid results

Data

- Pneumatic permeability
- Gas chemistry
- *In situ* distribution of moisture, pressure, and temperature

Data Use to Assess Impacts Covered Primarily by One Study Plan

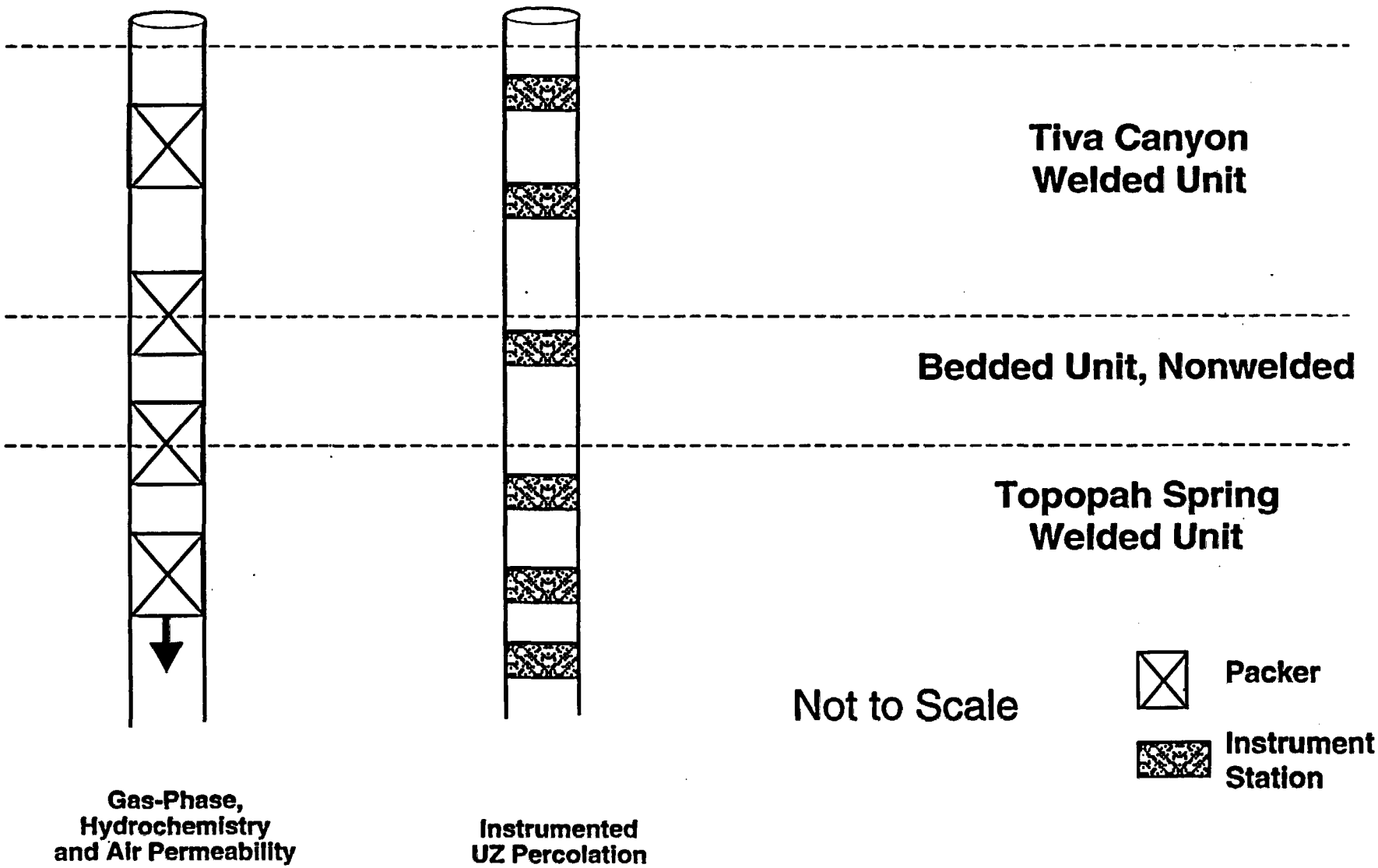
Study 8.3.1.2.2.8

- Fluid flow in unsaturated, fractured rock
  - Models to help design and interpret hydrologic and pneumatic tests
  - Provide information about model parameters that can be incorporated into site-scale models

Applicable Methods/Tests

- **Gas-phase circulation**
  - Flow surveys
  - Selected gas chemistry (CH_4, $C0_2$)
  - Shut-in pressures
- **Unsaturated zone hydrochemistry**
  - Large-scale borehole gas sampling
  - Long-term periodic gas sampling
- **Unsaturated zone percolation, surface-based study**
  - Air-permeability testing
  - *In situ* long-term monitoring of moisture, pressure, and temperature

SIMPLIFIED BOREHOLE TEST CONFIGURATIONS



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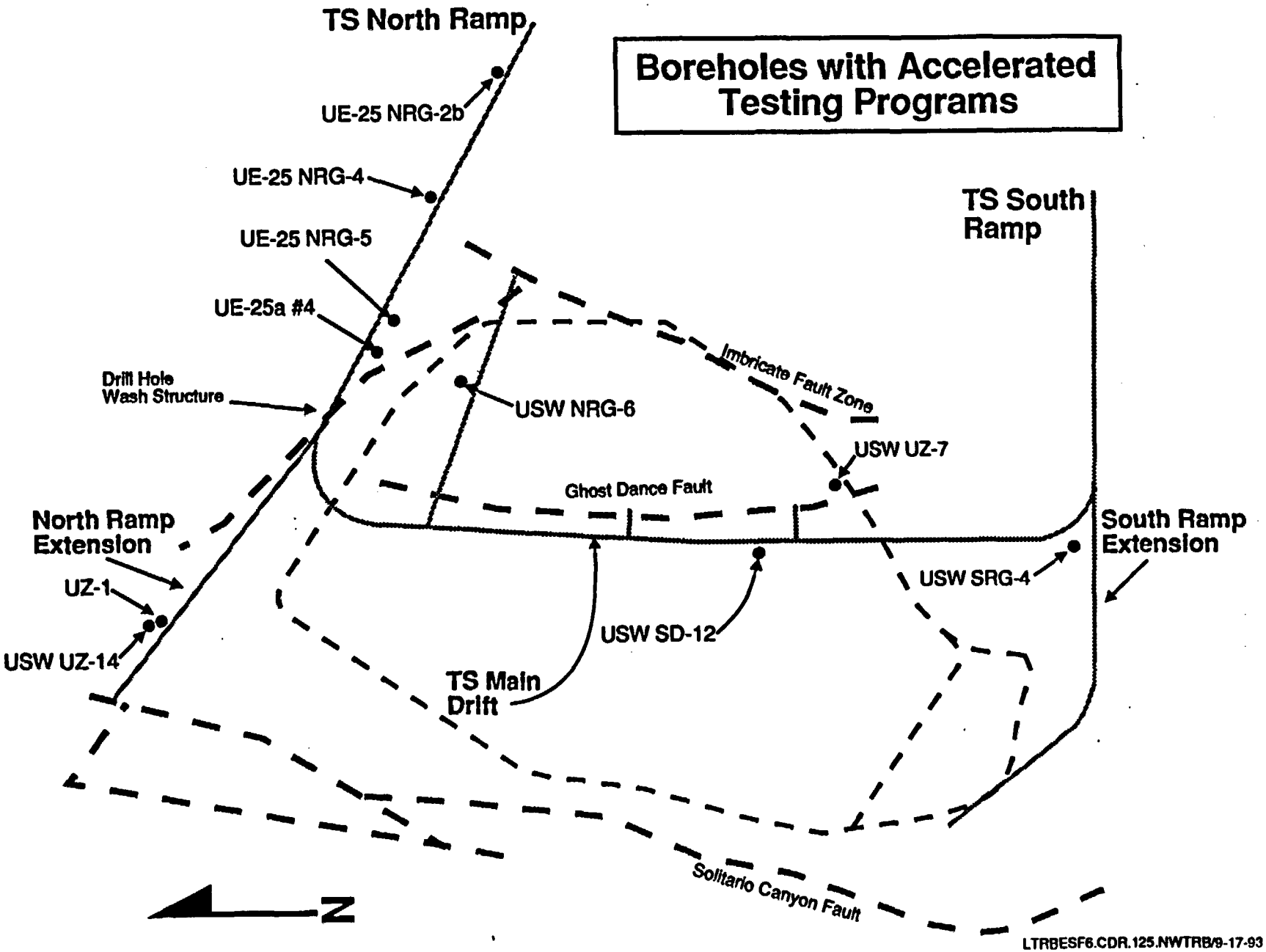
Experience to Date in Obtaining Similar Data

- USW UZ-1
  - Instrumentation
  - Gas sampling
- G-Tunnel
  - Development of instrumentation methods
- Hydrologic Research Facility auger holes
  - Demonstration of instrumentations methods
- USW UZ-6/6s
  - Ongoing study; topographic effects, barometric effects
- Apache Leap
  - Air-permeability prototype testing with packer systems


Boreholes with Accelerated Testing Programs
TS North Ramp
UE-25 NRG-2b
UE-25 NRG-4
UE-25 NRG-5
UE-25a #4
Drill Hole Wash Structure
USW NRG-6
Imbricate Fault Zone
USW UZ-7
Ghost Dance Fault
TS South Ramp
South Ramp Extension
USW SRG-4
North Ramp Extension
UZ-1
USW UZ-14
USW SD-12
TS Main Drift
Solitario Canyon Fault
N
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Pre-ESF Construction Data Collection

UE-25a#4	• Monitor gas pressures; shut-in pressures to overlap with USW NRG-6
UE-25 NRG-2b	• Flow surveys • Selected gas chemistry collected from tubing in open hole • Isolated gas chemistry and shut-in pressures; round-robin with seasons, continuous, as TBM approaches
UE-25 NRG-4	• Flow surveys • Selected gas chemistry collected from tubing in open hole • Isolated gas chemistry and shut-in pressures; round-robin with seasons, continuous, as TBM approaches
UE-25 NRG-5	• Flow surveys • Selected gas chemistry collected from tubing in open hole • Isolated gas chemistry and shut-in pressures; round-robin with seasons, continuous, as TBM approaches
USW NRG-6	• Flow surveys • Selected gas chemistry collected from tubing in open hole • Isolated gas chemistry and shut-in pressures • Air permeability testing • Instrument; long-term monitoring for pressure, water potential, and temperature; periodic gas sampling

Pre-ESF Construction Data Collection

(Continued)

USW UZ-14	• Geophysical logging • Gas-phase testing • Gas-chemistry sampling • Air-permeability testing • Instrument for long-term monitoring; periodic gas sampling
USW UZ-7	• Geophysical logging • Gas-phase testing • Gas-chemistry sampling • Air-permeability testing • Instrument for long-term monitoring; periodic gas sampling
USW SD-12	• Geophysical logging • Gas-phase testing • Gas-chemistry sampling • Air-permeability testing • Instrument for long-term monitoring; periodic gas sampling
USW SRG-4	• Geophysical logging • Gas-phase testing • Gas-chemistry sampling • Air-permeability testing • Instrument for long-term monitoring; periodic gas sampling

Pre-ESF Construction Data Collection

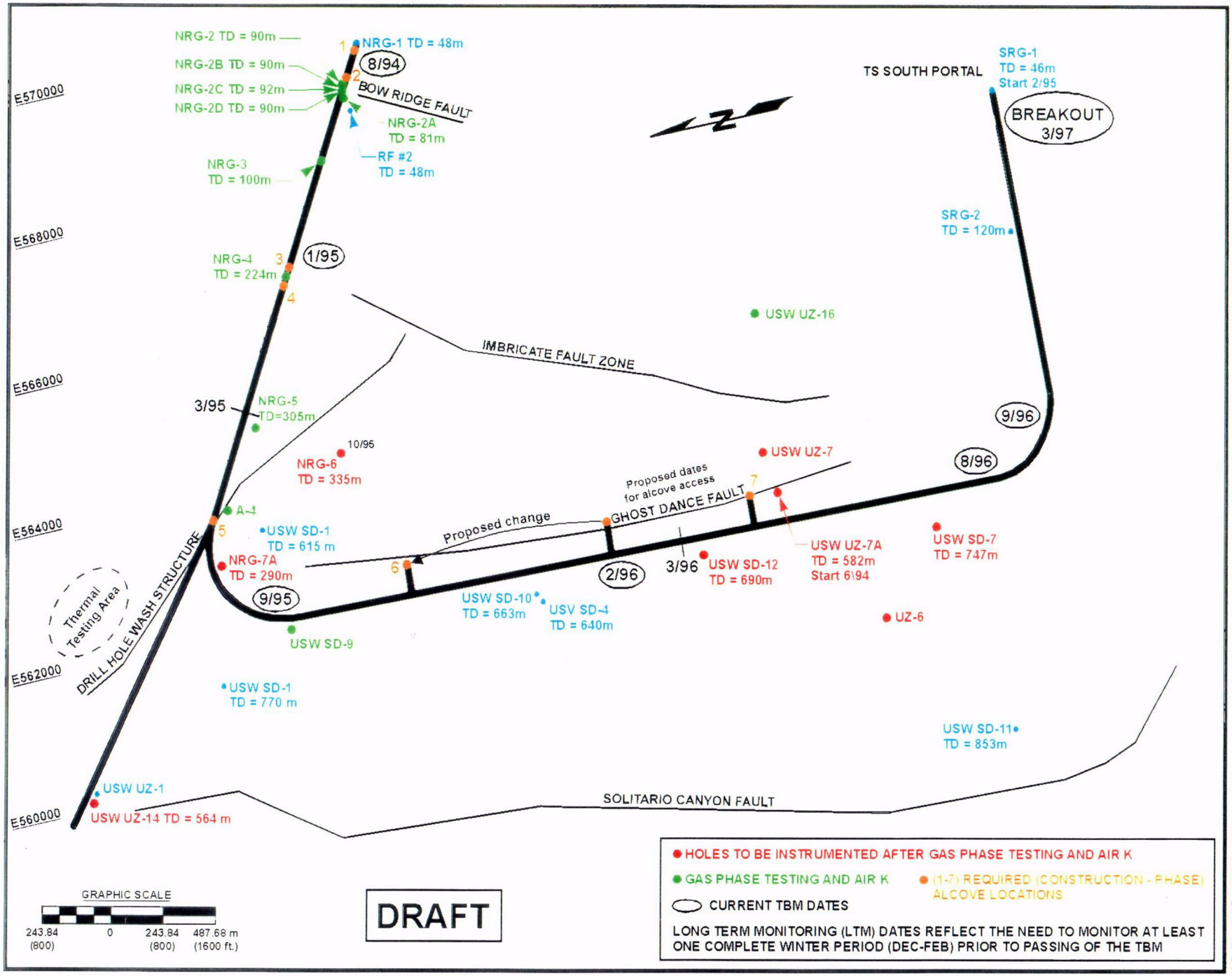
(Continued)

		STUDY			
		Gas Phase	UZ Hydro-chemistry	UZ Percolation	
Well	Status			Air-K	Instrument
USW NRG-6	Existing	X	X	X	X
UE-25a#4	Existing	X			
UE-25 NRG-2b	Existing*	X			
UE-25 NRG-4	Existing*	X			
UE-25 NRG-5	Existing*	X			
USW UZ-7	Existing*	X	X	X	X
USW UZ-14	In progress	X	X	X	X
USW SD-12	Planned	X	X	X	X
USW SRG-4	Planned	X	X	X	X

* Requires 6 inch diameter borehole and/or casing pulled.

Summary

Collection of pre- and concurrent-ESF construction pneumatic, gas chemistry, and *in situ* moisture, pressure, and temperature data will be accomplished to account for ESF impacts on site characterization efforts



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NRG, SRG, SD AND UZ BORHOLE ESF LOCATIONS AND SCHEDULE

ENCLOSURE 2

SURFACE BASED TESTING PROCEDURES

- Evacuate Drilling Air	< 1 mo
- Hydrochem Sample (Packers)	~ 1 mo
- Flow Survey	~ 1 day
- Shut in Pressures	~ 2 wk
- Air K Testing	~ 2 mo
- Evacuate Air K Tracer Gas	< 1 mo
- Hydro Chem Sample (Packers)	~ 1 mo
- Shut in Pressues	~ 2 wk
- Flow Survey	~ 1 day
- Stem Hole	< 1 mo
- Begin Longterm Monitoring	

ENCLOSURE 3

Borehole	Isotopes	Composition	Flow Survey	Shut Ins	H/T	Tracer
UZ6	P/F	P/F	P/F	P/F	P/F	-
UZ6s	P/F*	P/F*	P/F	P/F*	P/F*	P/F*
Neutrons	P/F	P/F	P/F	P/F	P/F	P/F
NRG 2b	P/F*	P/F*	F	F*	F*	F*
NRG 4	P/F*	P/F*	F	F*	F*	F*
NRG 5	F*	P/F*	F	F*	F*	F*
NRG 6 (AK)	P/F*	P/F*	F	P/F*	F*	F*
NRG 7 (AK)	F*	P/F*	F	F*	F*	F*
A4	-	-	-	P	-	-
UZ 16 (AK)	P/F*	P/F*	P/F	P/F*	F	-
UZ 1	P/F▲	P/F▲	-	P▲	P▲	P/F▲
UZ 14 (AK)	F	F	F	F	F	P/F
UZ 13 (AK)	P/F	P/F	F	P/F	F	-
UZ 7a (AK)	F	F	F	F	F	-
SD 10 (AK)	F	F	F	F	F	-
SD 12 (AK)	F	F	F	F	F	-
UZ 4 (AK)	P	P	-	P	P	-
UZ 5 (AK)	P/F	P/F	F	P/F	P/F	-
SRG 4 (AK)	F*	F*	F*	F*	F*	-
SD 4 (AK)	F	F	F	F	F	-
ESF (AK)	F*	P/F*	F*	F*	F*	F*
SRG 3 (AK)	F*	F*	F	F*	F*	-

* Discrete as well as nondisrete
(AK) Air permeability testing
▲ Stemmed

P - Past F - Future - Not Done

Testing Plans Table

ENCLOSURE 4