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

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: A FEATURES-BASED DRILLING APPROACH FOR DEEP PERCOLATION STUDIES AT YUCCA MOUNTAIN

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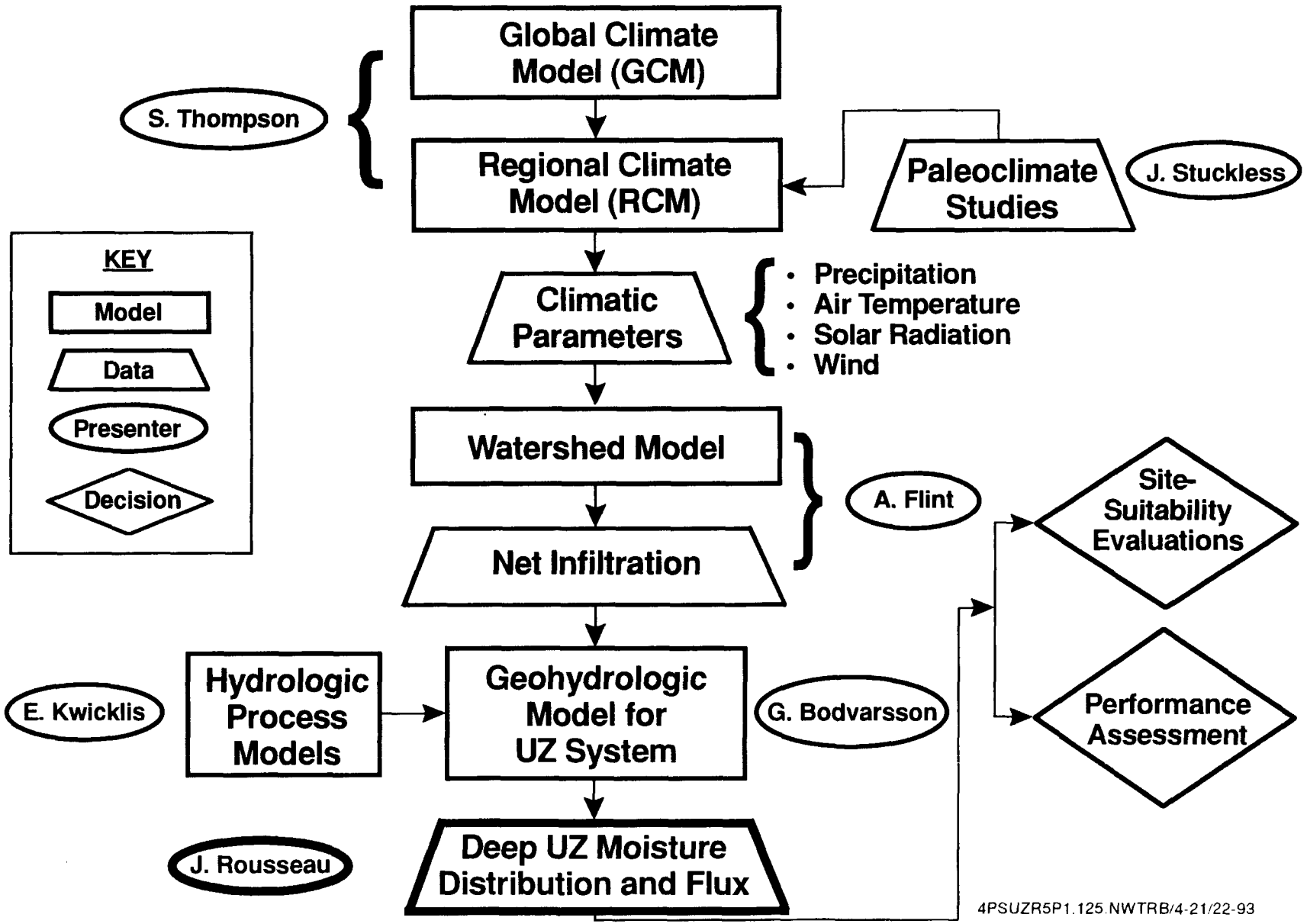
RENO, NEVADA
APRIL 21-22, 1993

Example Model Hierarchy



Presentation Outline

- Purpose and objectives
- Overview of percolation studies
- Borehole siting strategy
- Existing data base
- Setting priorities
- Changes in study
- Preliminary findings and possible interpretations -UZ#16

Achieving study goals

Purpose and Objectives

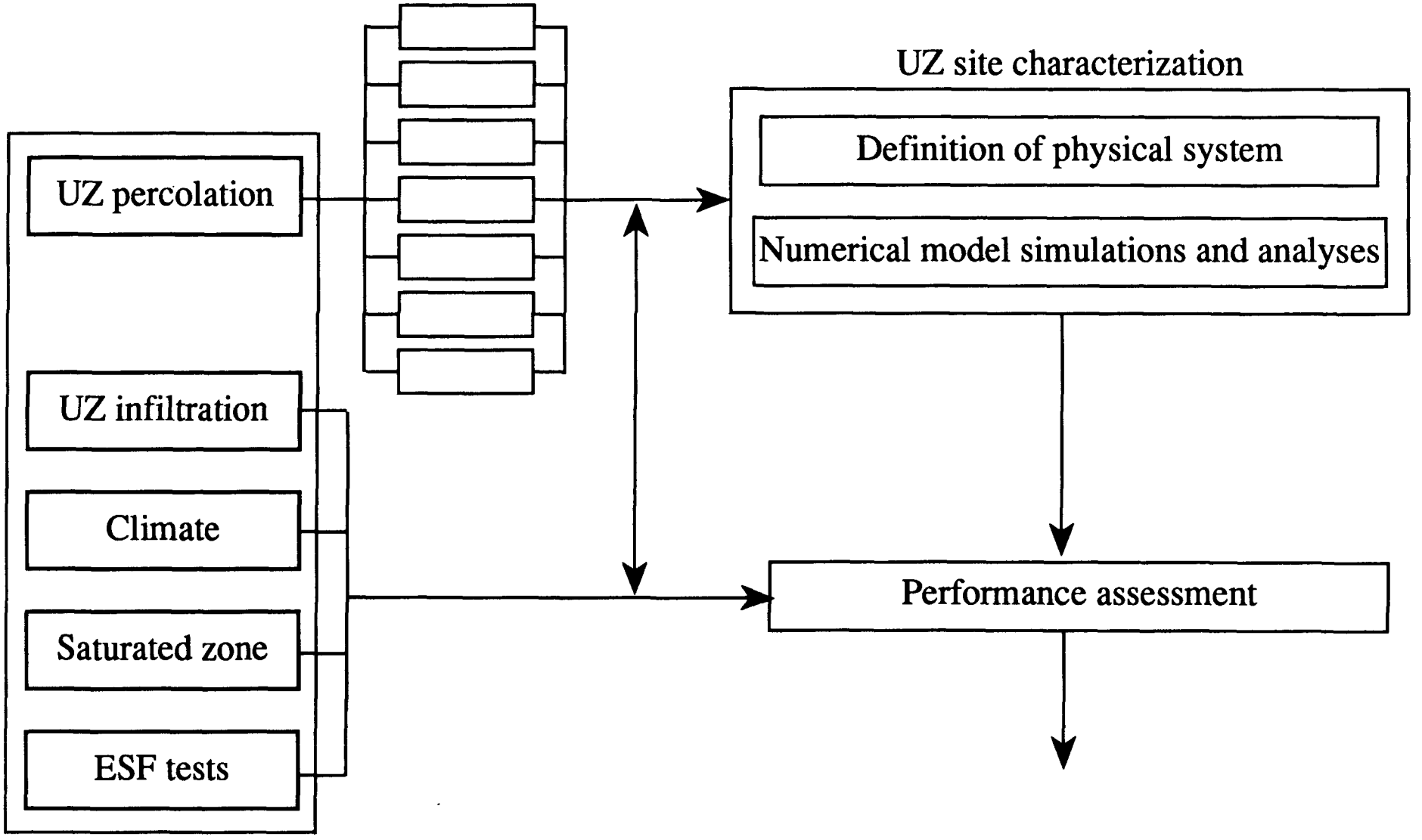
To characterize current flux in the unsaturated zone at Yucca Mountain, NV, through field and laboratory measurements of

- **Matrix hydrologic properties**
- **In situ permeability**
- **In situ fluid flow potentials**

  Uniform flux vs. concentrated flux

Overview of Percolation Studies

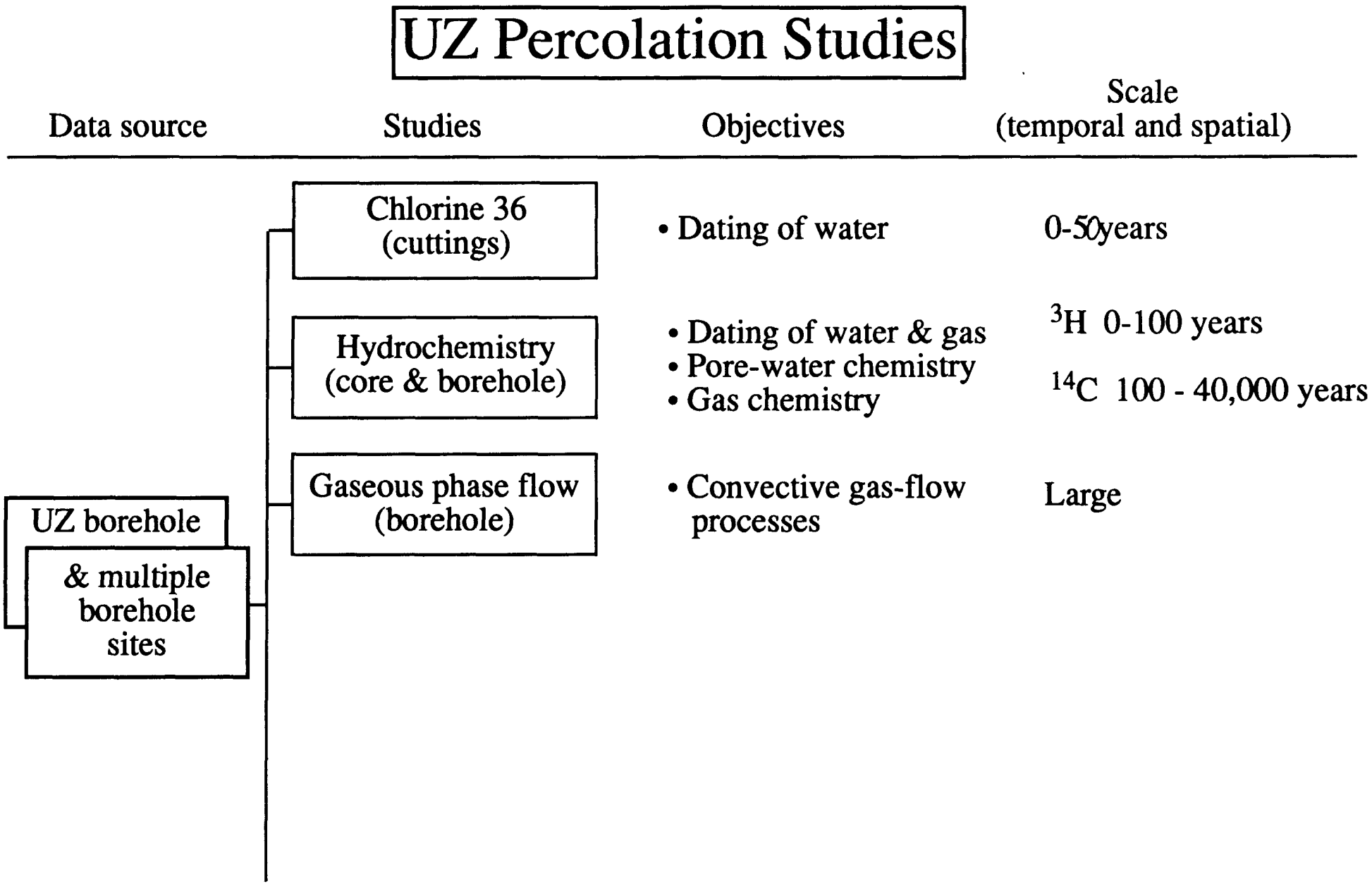
Relationship of Studies



UZ Percolation Studies

Data source	Studies	Objectives	Scale (temporal and spatial)
UZ borehole & multiple borehole sites	Chlorine 36 (cuttings)		
	Hydrogen (core & borehole)		
	Gaseous phase flow (borehole)		
	Matrix hydrologic properties (core)	• Porosity • Relative permeability • Moisture retention • Saturation & water potential	Small
	Air permeability testing (borehole)	• Fracture & matrix permeability • Fracture inter-connectedness	Medium to large
	Fluid flow potentials (borehole)	• Pneumatic pressure, temperature & water potential • Flow directions & gradients • System stability • Diffusion & saturation permeability	Large
	Vertical seismic profiling (borehole)	• 3-D subsurface imaging • Geologic structure • Fault/fracture system continuity	Very large

UZ Percolation Studies



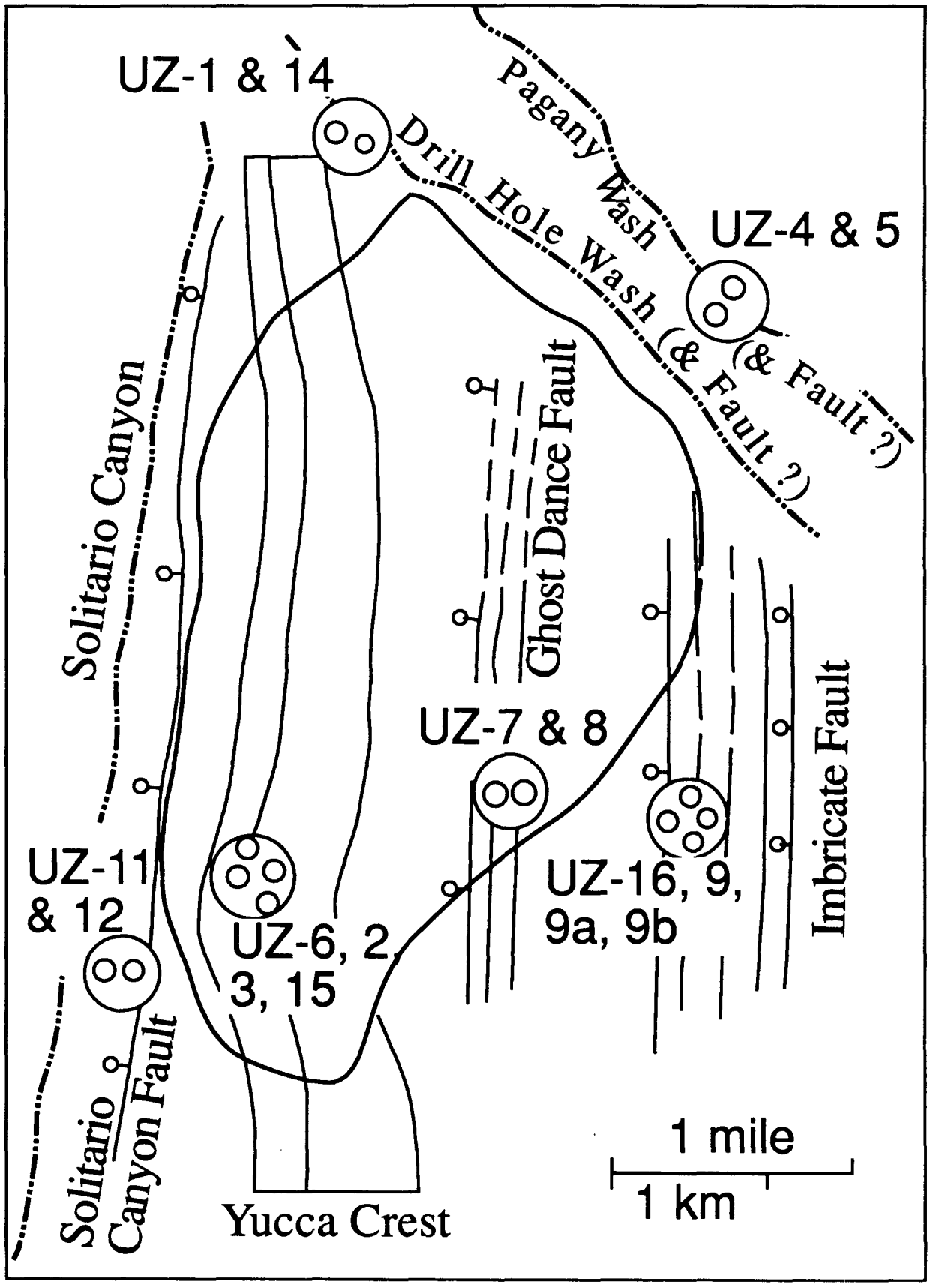
Siting Strategy

"...Target those areas of interest with the greatest potential to provide the evidence needed to assess the suitability of Yucca Mountain as a repository for high-level radioactive waste" (YMP-USGS-SP 8.3.1.2.2.3)

Siting Criteria

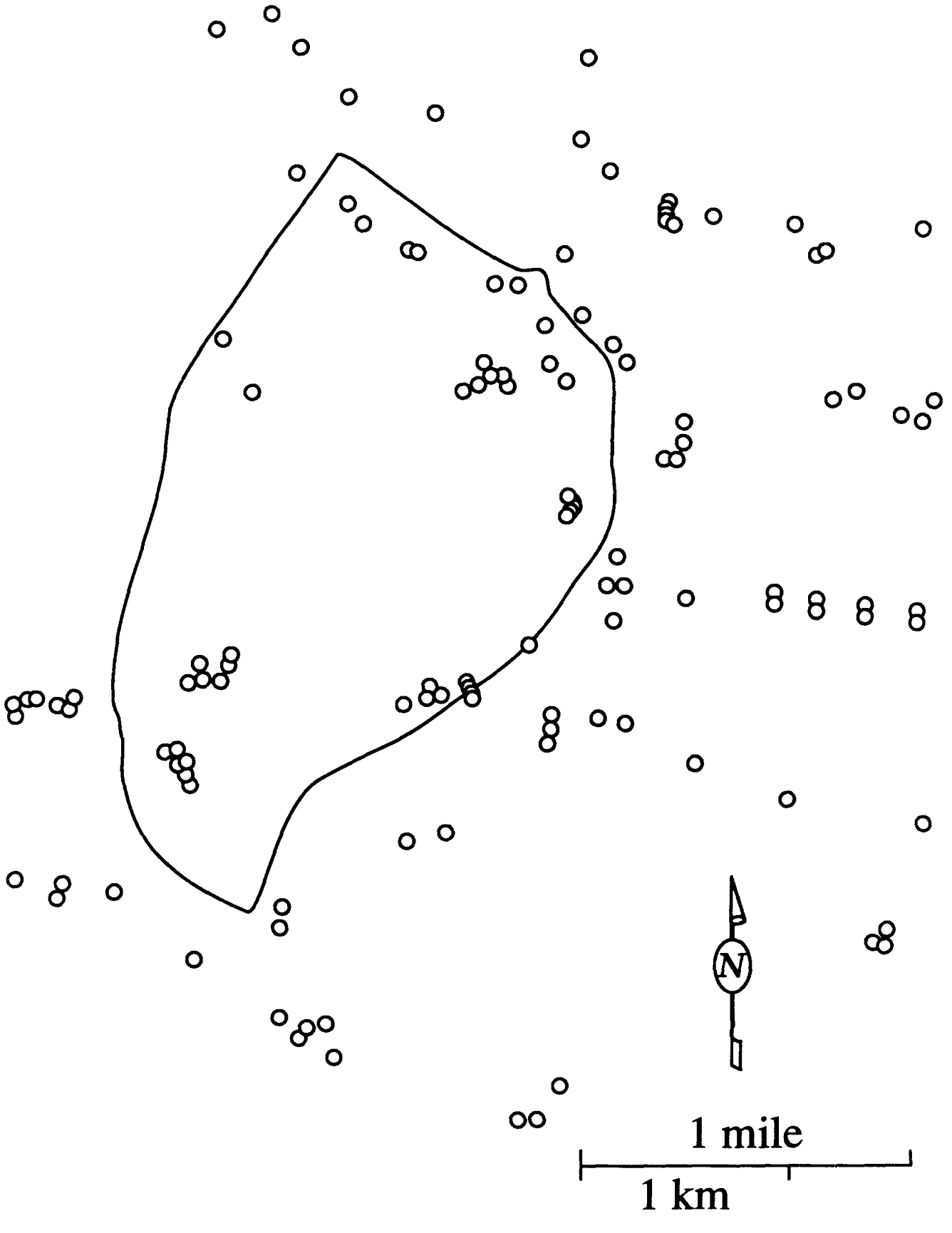
- Large-scale structural features
- Surface drainage features
- Topographic features

Features-Based Boreholes
Yucca Mountain, Nevada

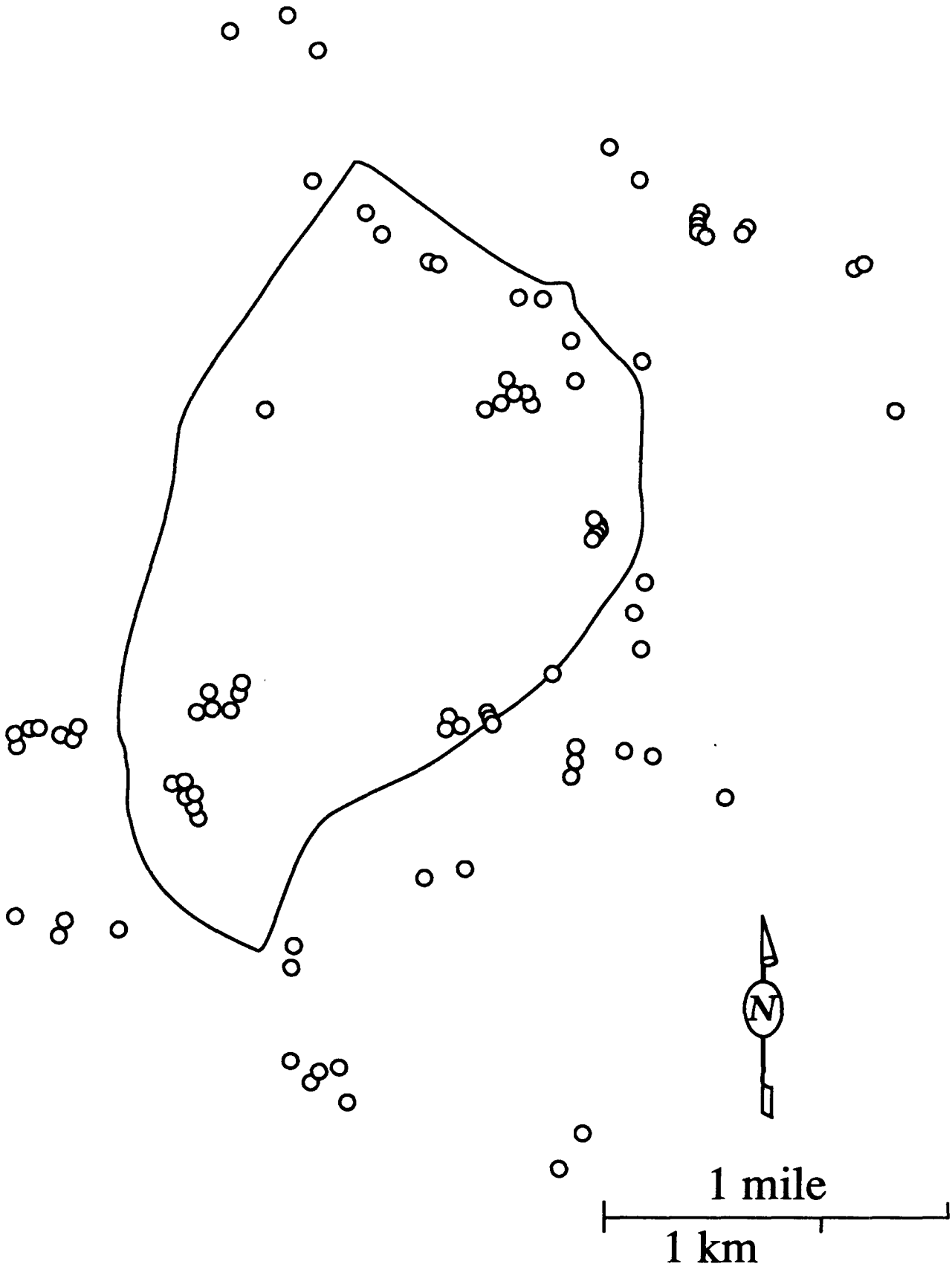


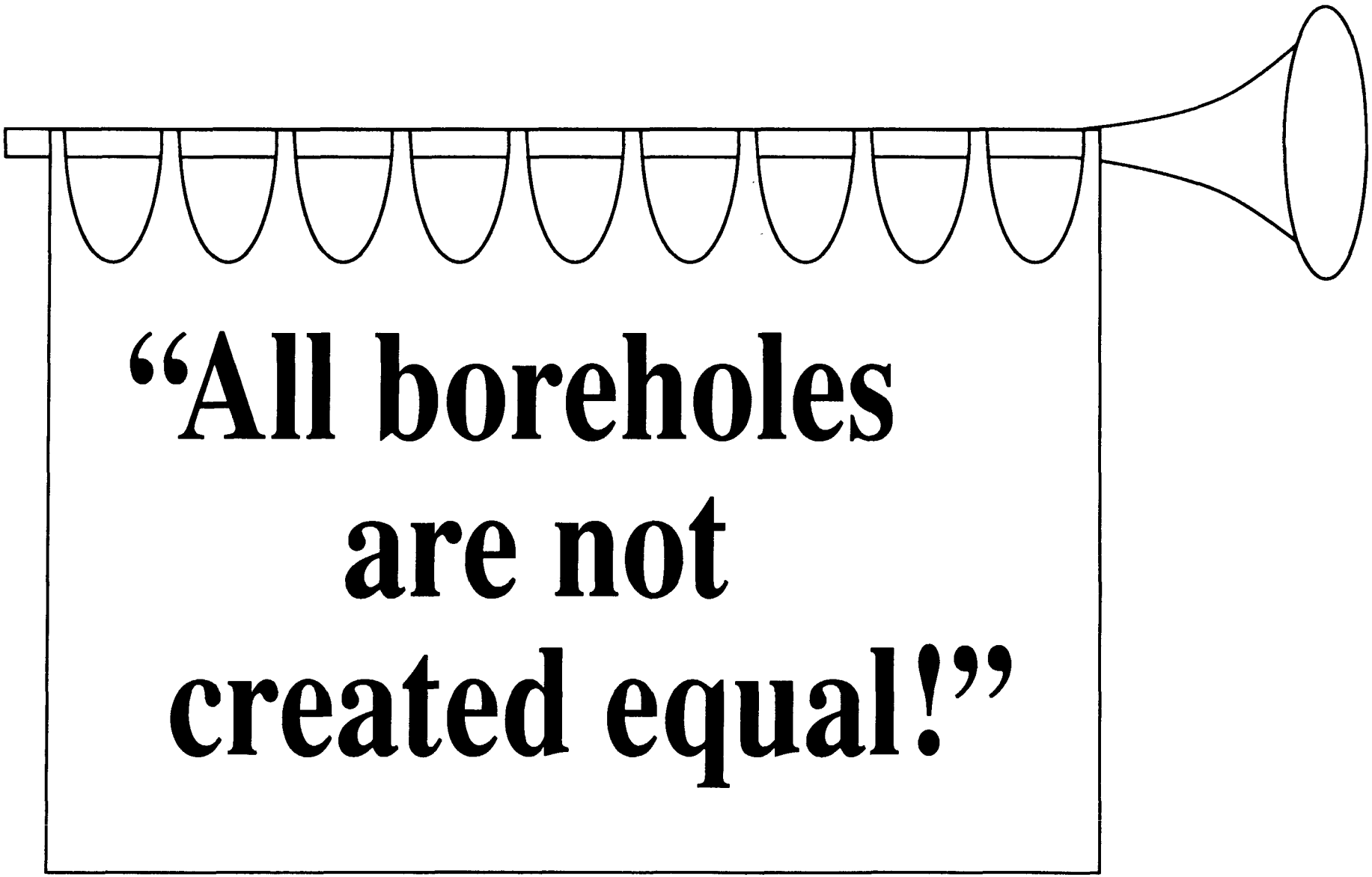
Existing Data Base for Deep Percolation Studies

Existing Boreholes in the Vicinity of Yucca Mountain

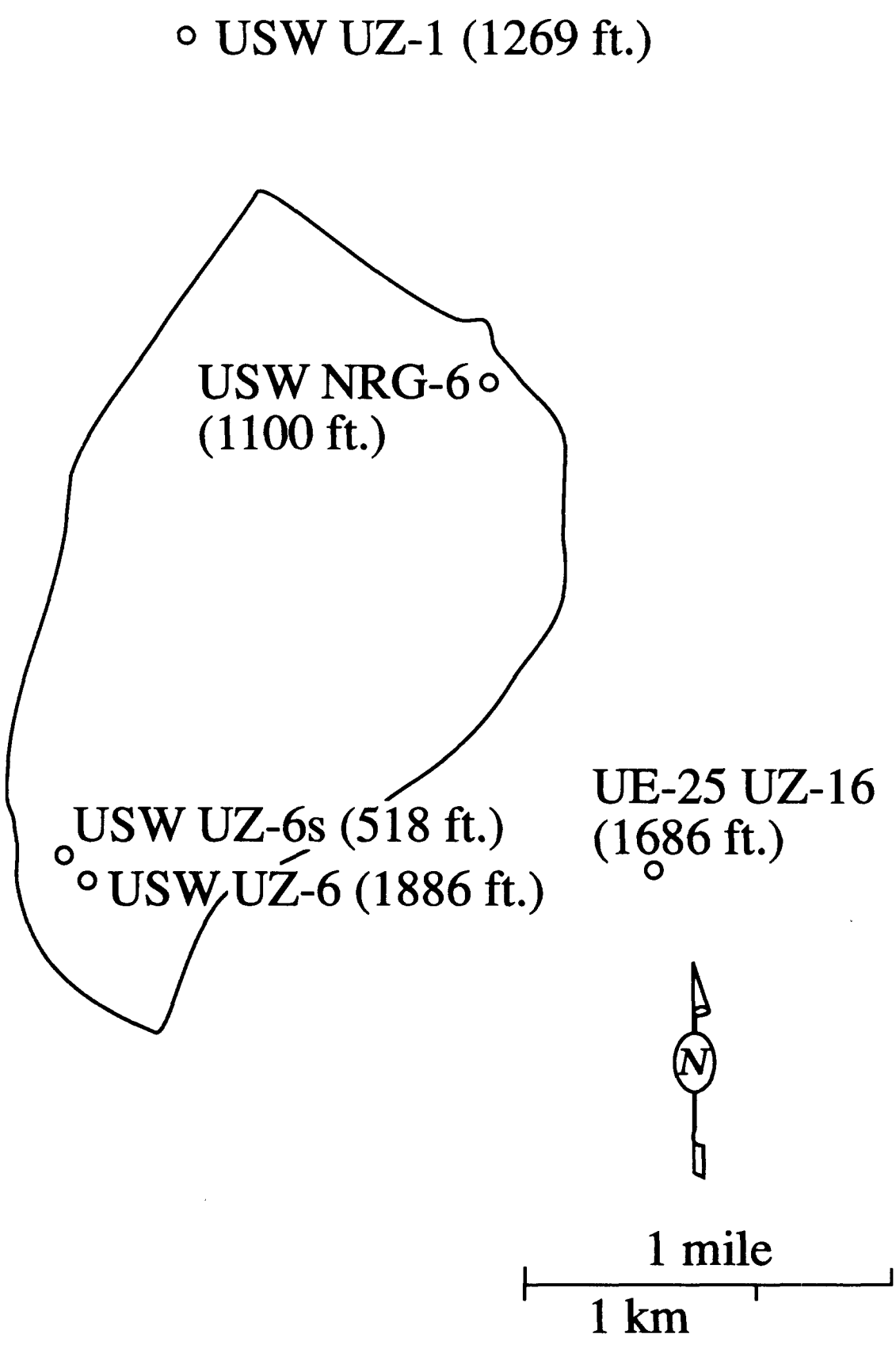


Existing Dry-Drilled Boreholes in the Vicinity of Yucca Mountain

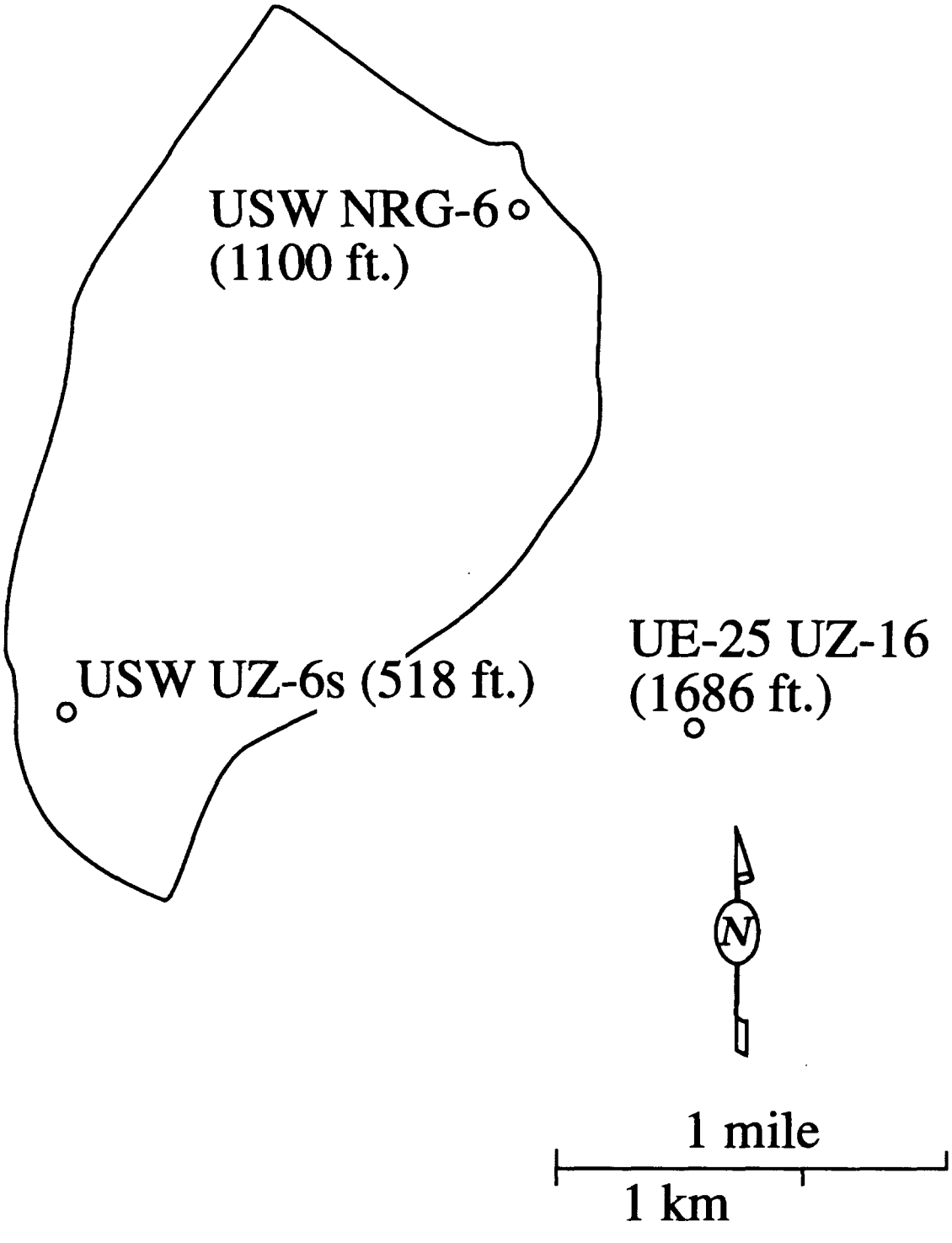



"All boreholes
are not
created equal!"

Existing Dry-Drilled Boreholes, Deeper than 500 feet, in the Vicinity of Yucca Mountain



Existing Cored, Dry-Drilled Boreholes, Deeper than 500 feet, in the Vicinity of Yucca Mountain

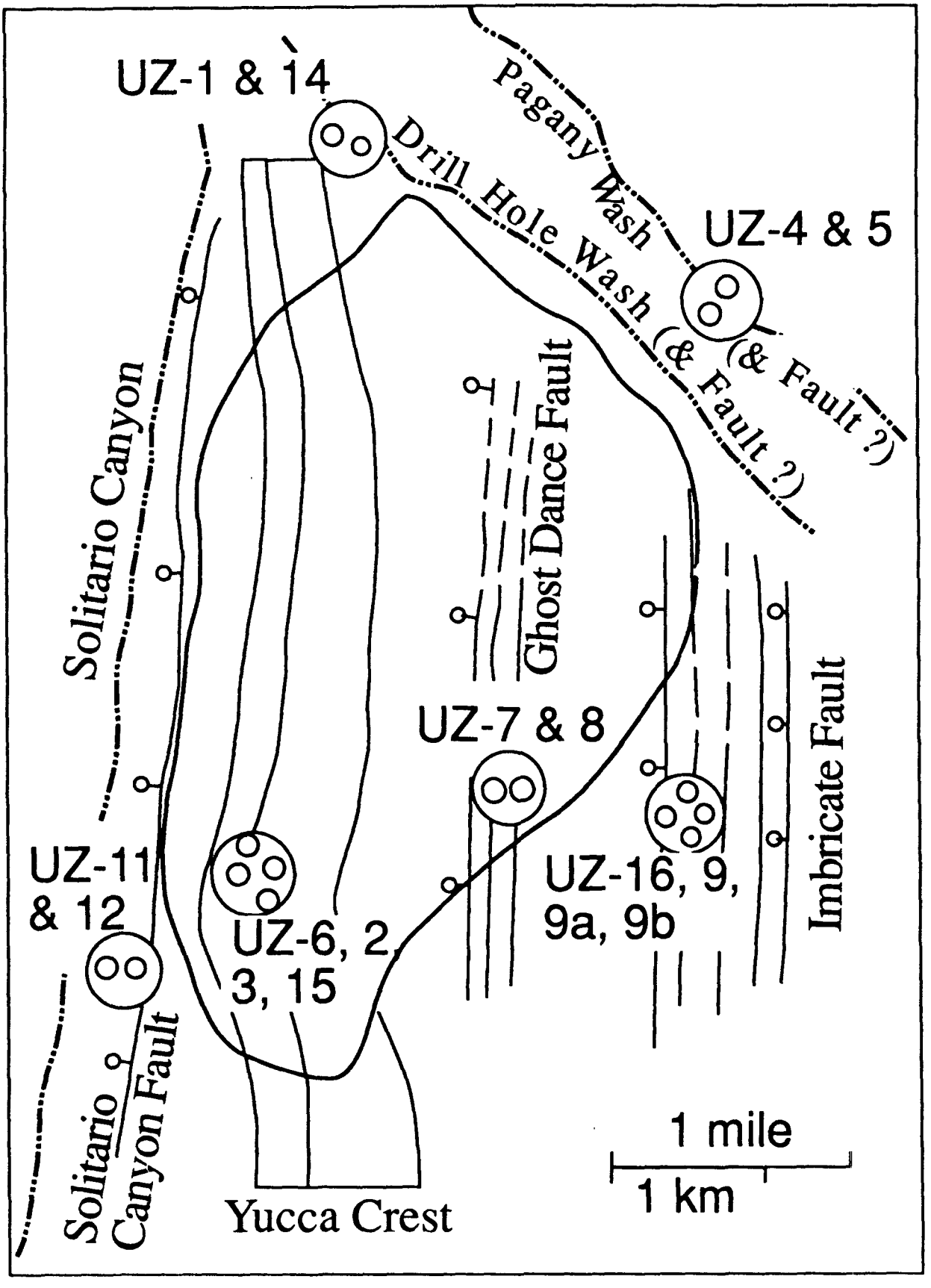


Drilling Sequence and Prioritization

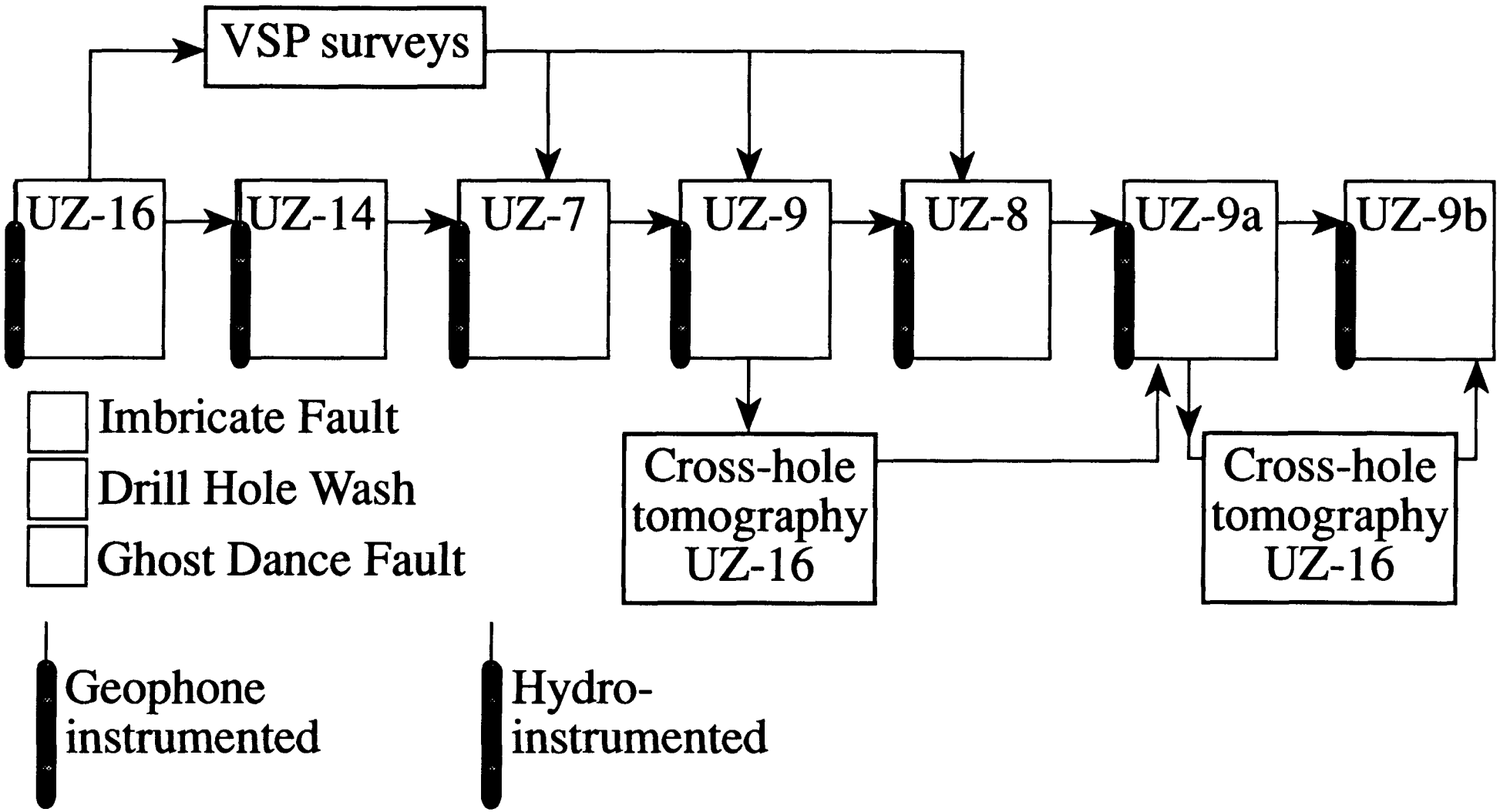
Setting Priorities

- Importance to early site-suitability assessments
- Operational and technical constraints
- Test interference constraints
- Optimize information return
- Funding and resource limitations

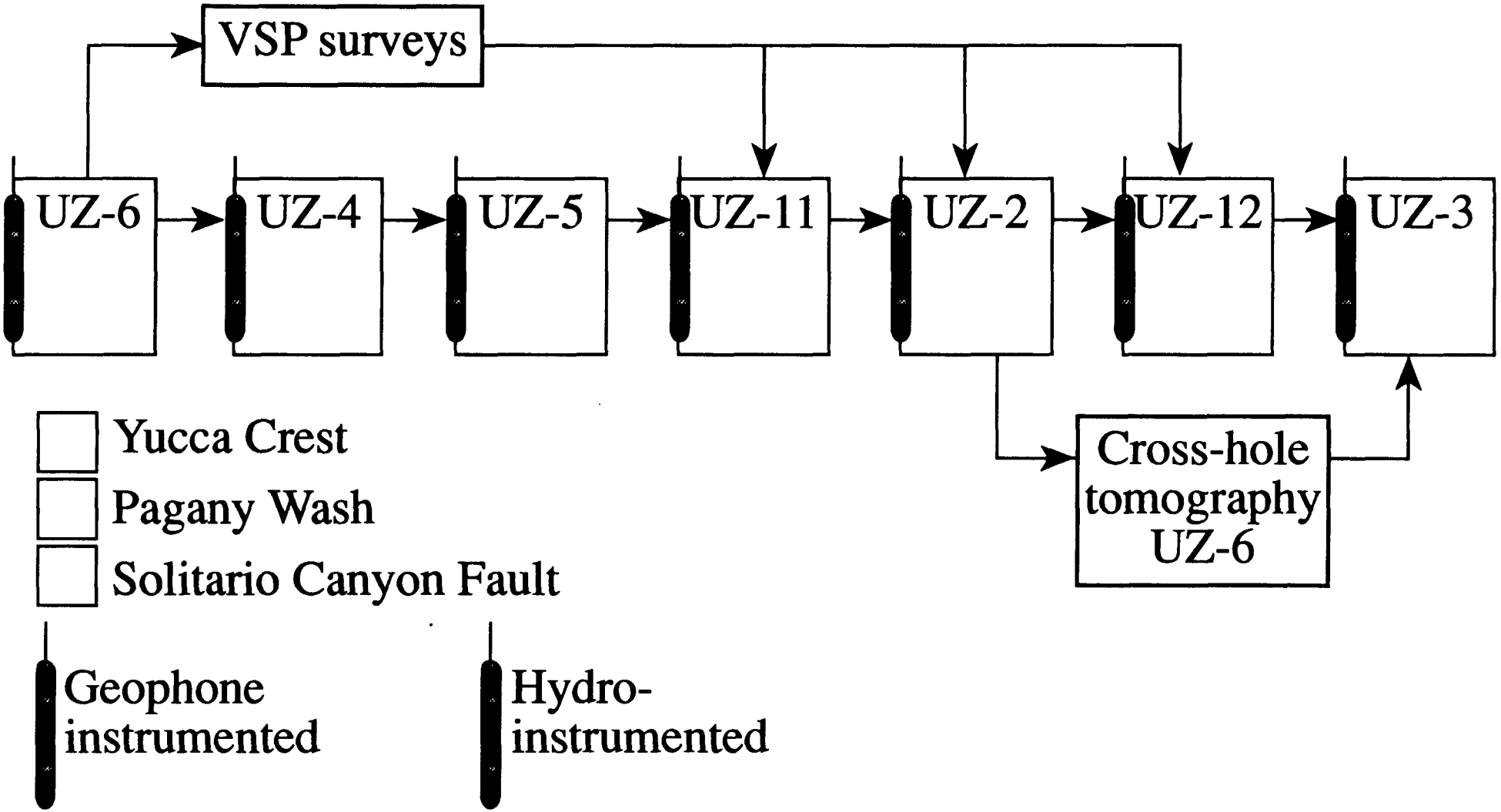
Features-Based Boreholes
Yucca Mountain, Nevada



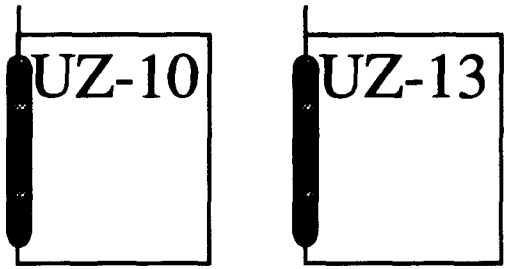
Drilling Sequence & Prioritization I



Drilling Sequence & Prioritization II



Drilling Sequence & Prioritization III



or select Sandia boreholes
(systematic drill holes)

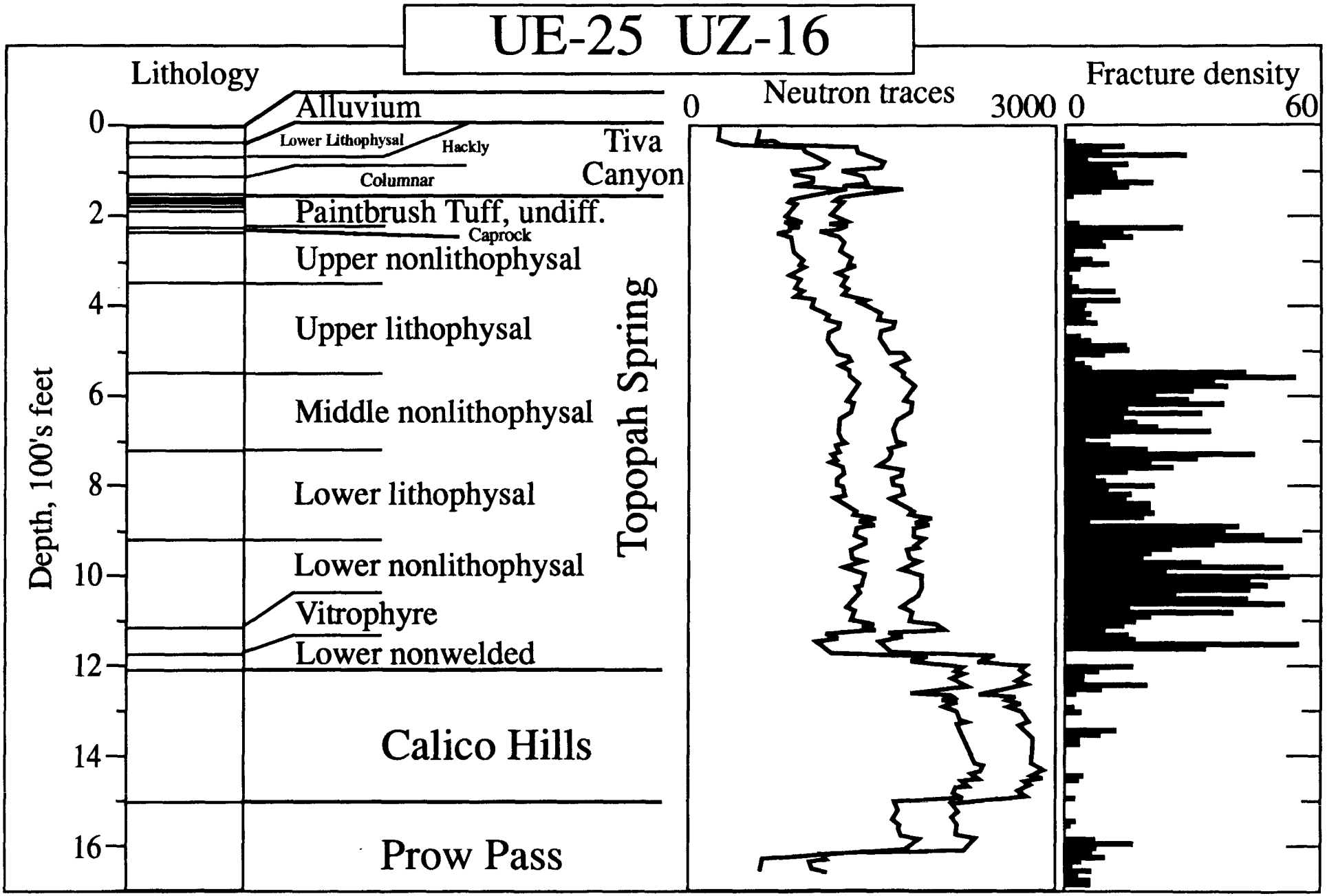
Non-structurally controlled boreholes

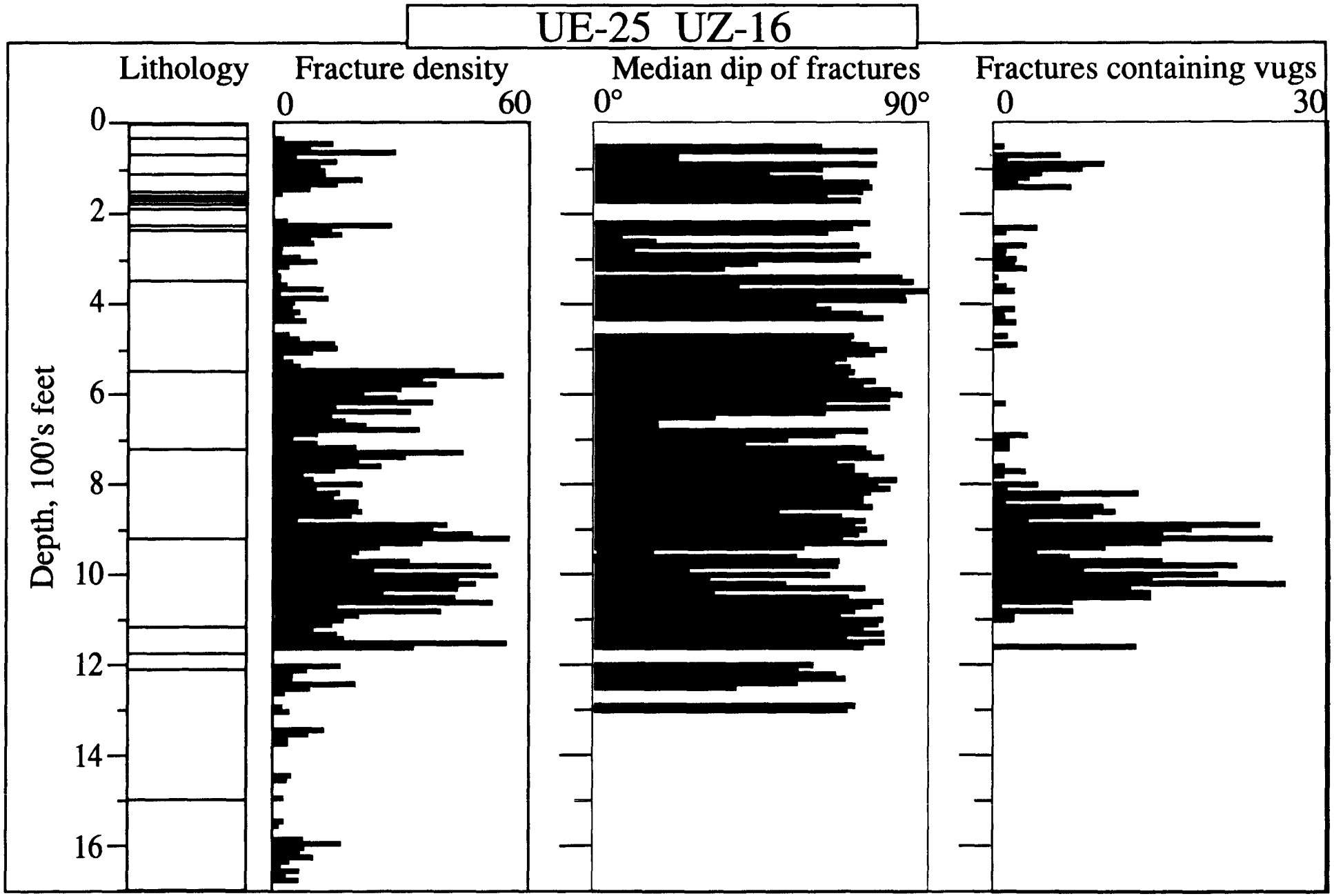
Hydro-
instrumented

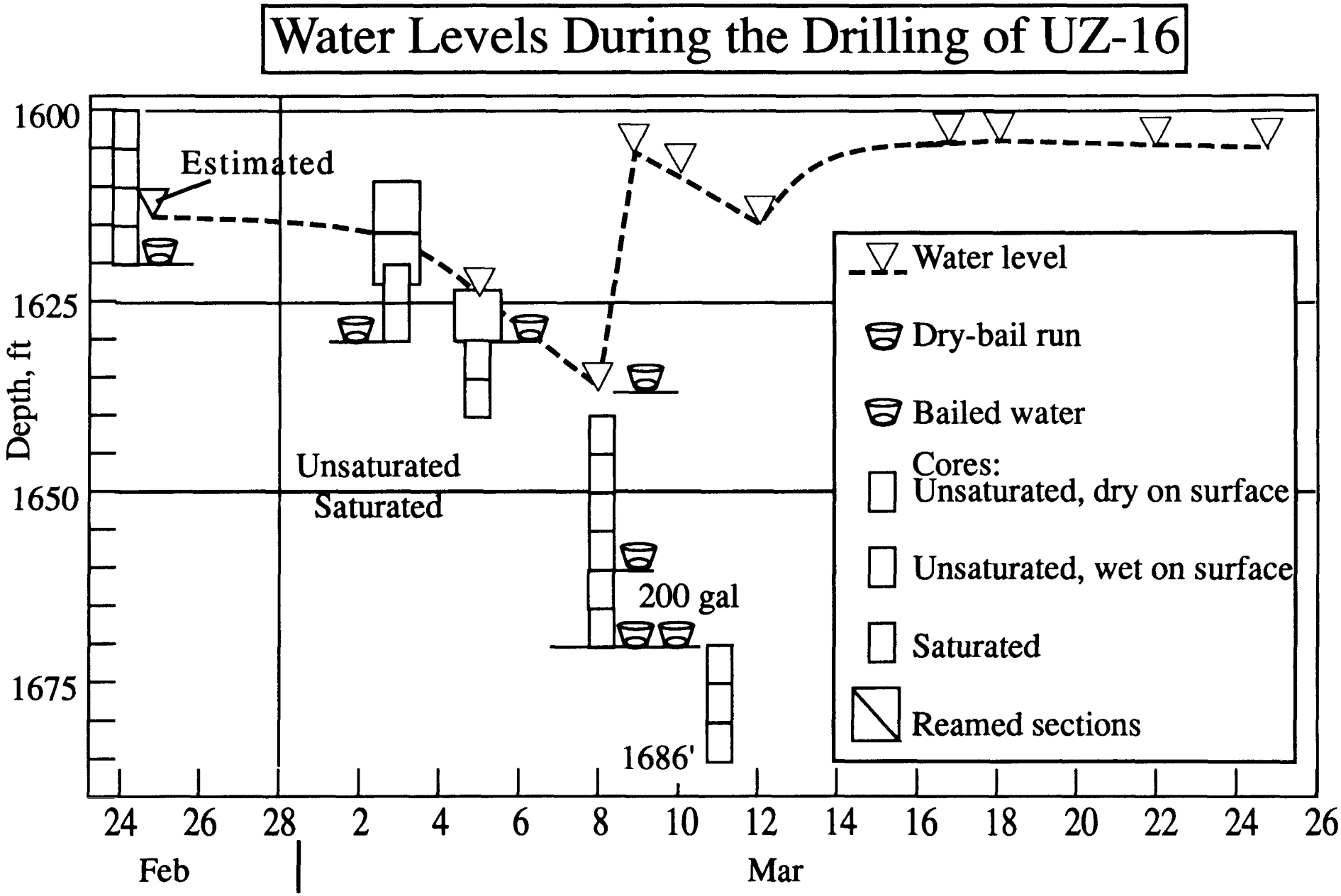
Changes In Study

- Limited changes to date
- Program in its infancy (15% of footage drilled)
- Inclusion of select number of systematic boreholes into testing and measurement program
- Possible elimination of boreholes outside of CPDB with inclusion of systematic boreholes
- Possible reduction in depths and coring requirements at multiple borehole sites

Preliminary Findings
UE-25 UZ#16


UE-25 UZ-16
Lithology
Neutron traces
Fracture density
0
3000
0
60
Depth, 100's feet
0
2
4
6
8
10
12
14
16
Alluvium
Lower Lithophysal
Hackly
Columnar
Tiva Canyon
Paintbrush Tuff, undiff.
Caprock
Upper nonlithophysal
Upper lithophysal
Middle nonlithophysal
Lower lithophysal
Lower nonlithophysal
Vitrophyre
Lower nonwelded
Topopah Spring
Calico Hills
Prow Pass


UE-25 UZ-16
Lithology
Fracture density
0
60
Median dip of fractures
0°
90°
Fractures containing vugs
0
30
Depth, 100's feet
0
2
4
6
8
10
12
14
16


Water Levels During the Drilling of UZ-16
1600
1625
1650
1675
Depth, ft
Estimated
Unsaturated
Saturated
200 gal
1686'
Water level
Dry-bail run
Bailed water
Cores:
Unsaturated, dry on surface
Unsaturated, wet on surface
Saturated
Reamed sections
24
26
28
2
4
6
8
10
12
14
16
18
20
22
24
26
Feb
Mar

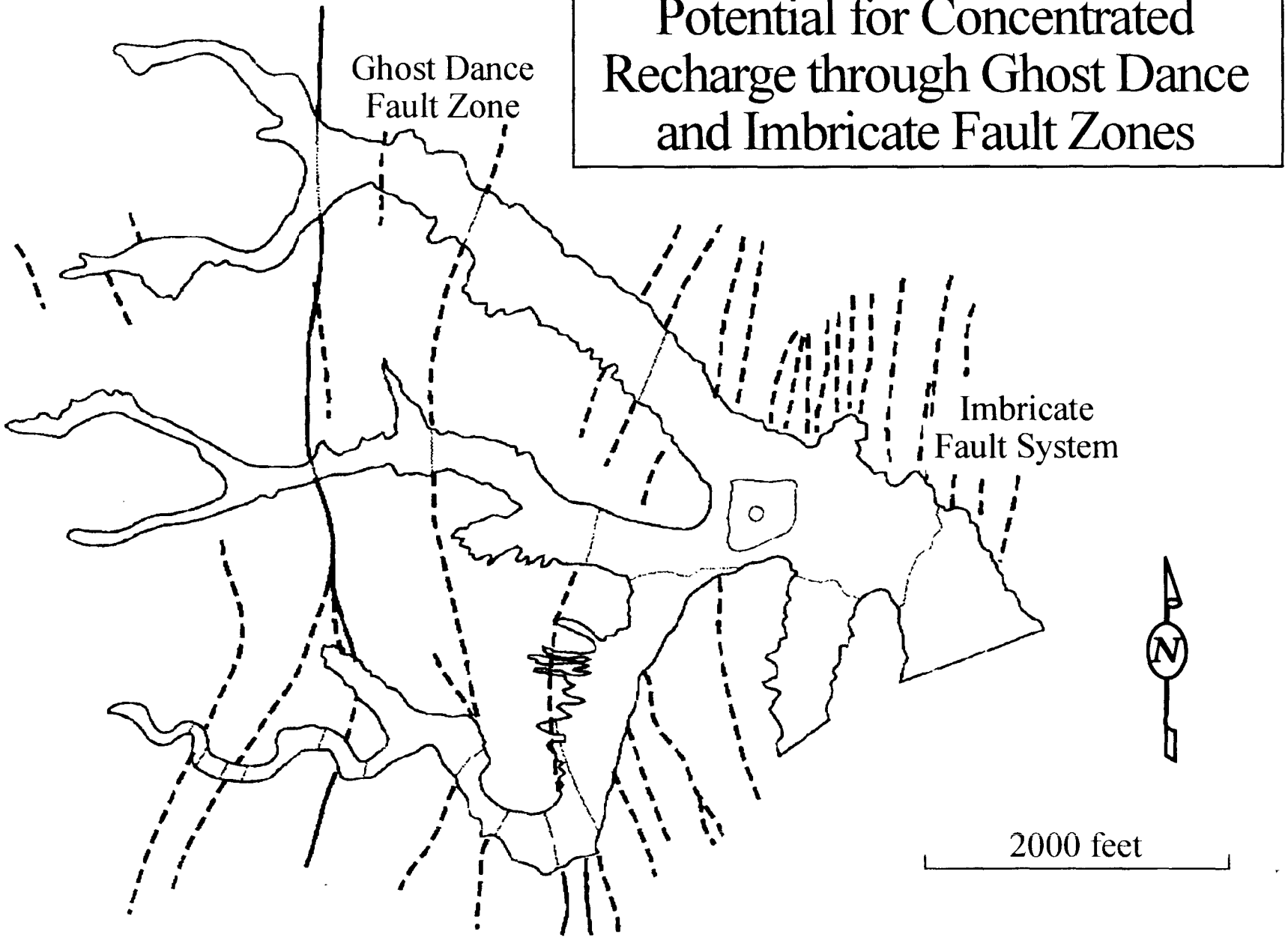
Preliminary Findings

UZ-16 (dry drilled and cored to saturated zone)

- Imbricate faults almost vertical
- Fracture density in Topopah Spring much greater than earlier estimates
  - Range: 50 to 250 per m^3
  - Average: 125 per m^3 vs 50 per m^3 (Montazer & Wilson, 1984)
- Water encountered in fractures in Prow Pass unit in non-saturated matrix environment

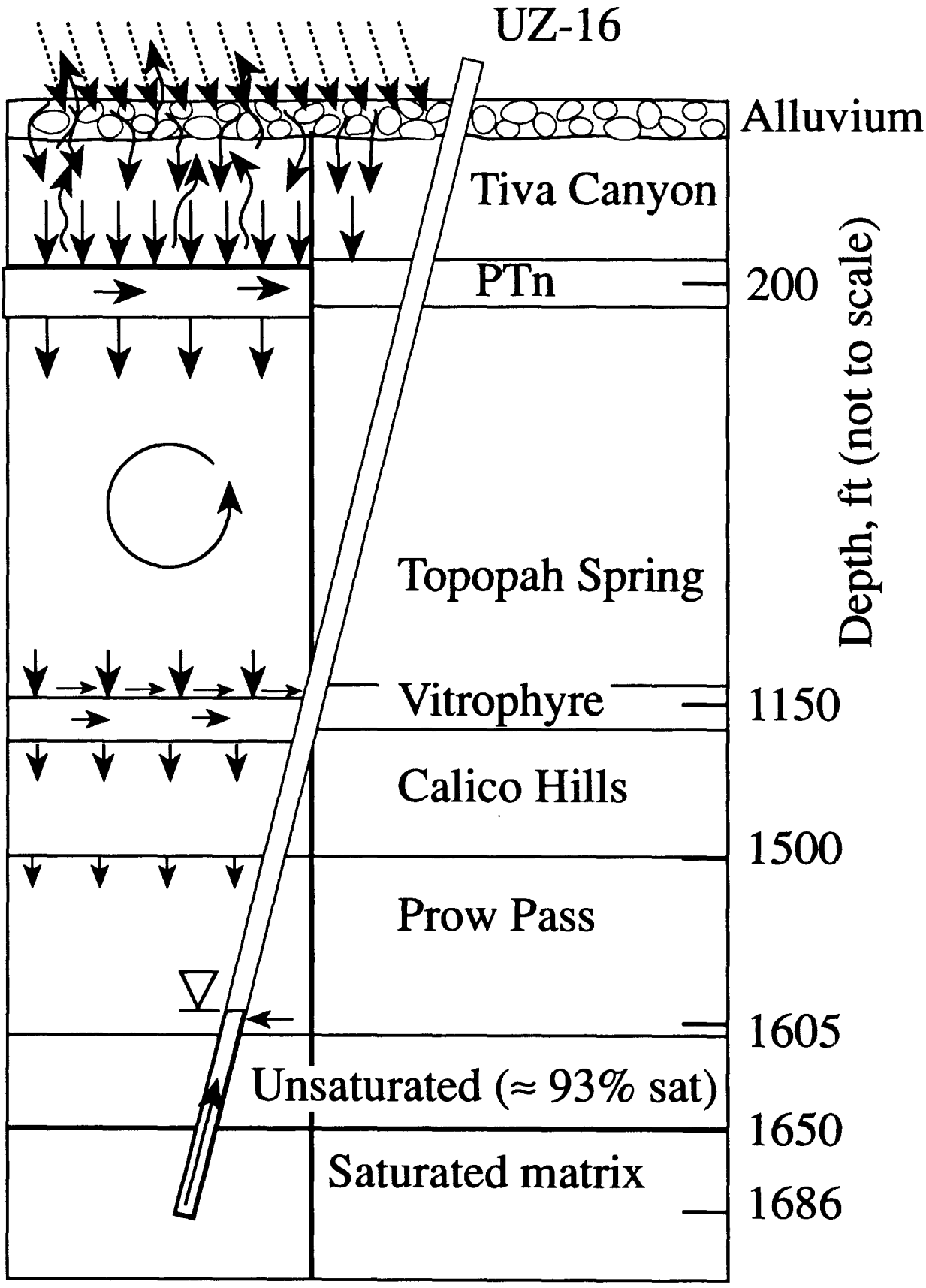
Possible Interpretations
UE-25 UZ#16

Potential for Concentrated Recharge through Ghost Dance and Imbricate Fault Zones



4PSUZR5P13.125.NWTRB/4-21/22-93

Conceptualization of Percolation



Possible Interpretations for Unsaturated Matrix - Fracture Flow at UZ-16

Uniform Flux

- Fracture flow in unsaturated matrix sustained by high-pressure heads and upward flow from the saturated Prow Pass

Concentrated Flux

- Fracture flow in unsaturated matrix sustained by downward fault flow derived from lateral inflow and/or near-surface infiltration

Possible Interpretations for Unsaturated Matrix - Fracture Flow at UZ-16

(Continued)

Perched Water

- **Residual water from higher piezometric and/or standing water levels in the Prow Pass**

  * **Matrix may be locally saturated near interconnected fractures and/or near adjacent fault zones**

Achieving Study Goals

Answer the question:
Is percolation a

a) Uniform flux problem

b) Concentrated flux problem

c) All of the above

d) None of the above

Photo of LM-300