

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

**NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING**

**SUBJECT: CLIMATE AND INFILTRATION
ISSUES ON ASSESSING THE SITE
SUITABILITY OF YUCCA MOUNTAIN**

PRESENTER: DR. JEREMY M. BOAK

**PRESENTER'S TITLE
AND ORGANIZATION: CHIEF, TECHNICAL ANALYSIS BRANCH
U.S. DEPARTMENT OF ENERGY
LAS VEGAS, NEVADA**

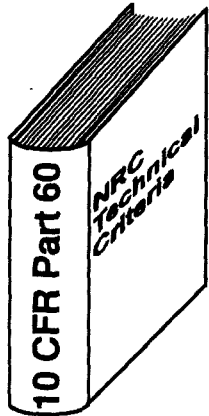
**PRESENTER'S
TELEPHONE NUMBER: (702) 794-7588**

**RENO, NEVADA
APRIL 21-22, 1993**

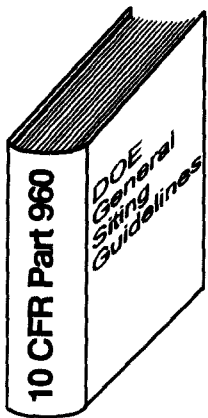
Overview

- **Regulatory basis**
- **Technical vs. regulatory view**
- **Role of performance assessment**

Regulatory Basis for Understanding Infiltration and Climate Change



- 60.112 Total System
- 60.113 Waste Package
- Engineered Barrier System
- Geologic Setting
- 60.122(b) Favorable Conditions
- 60.122(c) Potentially Adverse Conditions



- 960.4-2-4 Climatic Changes

Regulations Requiring Understanding of Infiltration and Climate Change

10 CFR Part 60 Performance objectives for total system (60.112), waste package (60.113), engineered barrier system (60.113), and geologic setting (60.113)

10 CFR Part 60.122

(b) *Favorable conditions*

- (6) For disposal in the unsaturated zone, hydrogeologic conditions that provide –
- i) Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units;
 - ii) A water table sufficiently below the underground facility such that fully saturated voids contiguous with the water table do not encounter the underground facility;
 - iii) A laterally extensive, low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward movement of water to a location beyond the limits of the underground facility;
 - iv) A host rock that provides for free drainage;
 - v) A climatic regime in which the average annual historical precipitation is a small fraction of the average annual potential evapotranspiration.
- (c) *Potentially adverse conditions*
- (5) Potential for changes in hydrologic conditions that would affect the migration of radionuclides to the accessible environment, such as changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.
- (6) Potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic conditions.
- (22) Potential for the water table to rise sufficiently so as to cause saturation of an underground facility located in the unsaturated zone.
- (23) Potential for existing or future perched water bodies that may saturate portions of the underground facility or provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment.

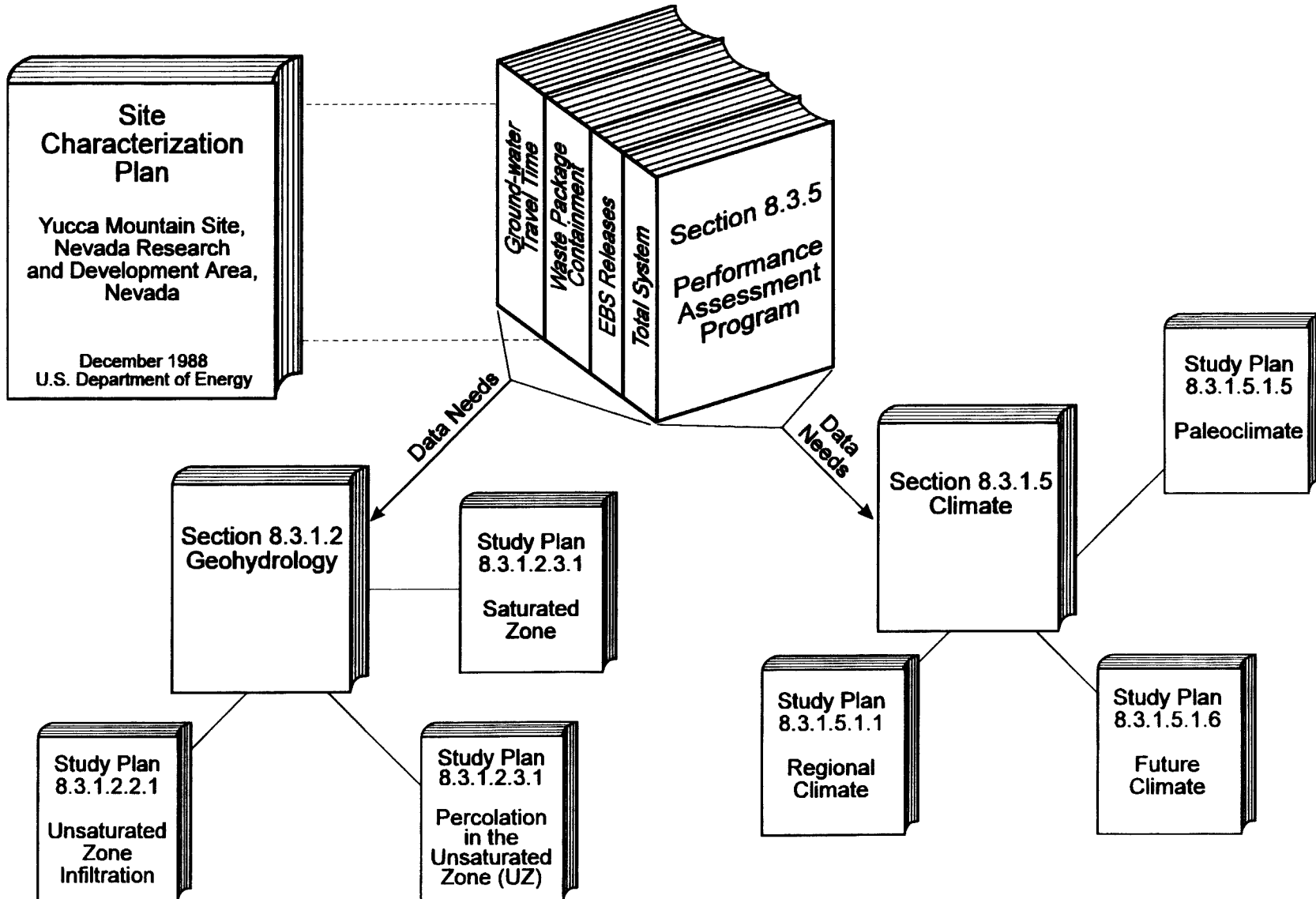
10 CFR Part 960.4-2-1 Geohydrology

- (a) *Qualifying Condition.* The geohydrologic setting, considering the characteristics of and the processes operating within the geologic setting, shall permit compliance with [the requirements]
- (b) *Favorable Conditions* (5) For disposal in the unsaturated zone, at least one of the following pre-waste-emplacment conditions exists:
- (i) A low and nearly constant degree of saturation in the host rock and in the immediately surrounding geohydrologic units.
 - (ii) A water table sufficiently below the underground facility such that the fully saturated voids contiguous with the water table do not encounter the host rock.
 - (iii) A geohydrologic unit above the host rock that would divert the downward infiltration of water beyond the limits of waste emplacement.
 - (iv) A host rock that provides for free drainage.
 - (v) A climatic regime in which the average annual historical precipitation is a small fraction of the average annual potential evapotranspiration.

10 CFR Part 960.4-2-4 Climatic changes

- (a) *Qualifying Condition.* The site shall be located where future climatic conditions will not be likely to lead to radionuclide releases greater than those allowable under [the requirements]
- (b) *Favorable Conditions* (1) A surface water system such that the expected climatic cycles over the next 100,000 years would not adversely affect waste isolation.
- (2) A geologic setting in which climatic changes have had little effect on the hydrologic system throughout the Quaternary Period.
- (c) *Potentially Adverse Conditions* (1) Evidence that the water table could rise sufficiently over the next 10,000 years to saturate the underground facility in a previously unsaturated host rock.
- (2) Evidence that climatic changes over the next 10,000 years could cause perturbations in the hydraulic gradient, the hydraulic conductivity, the effective porosity, or the ground-water flux through the host rock and the surrounding geohydrologic units, sufficient to significantly increase the transport of radionuclides to the accessible environment.

Site Characterization Plan

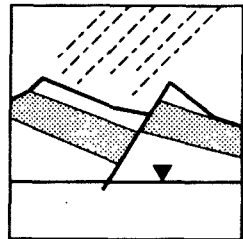


**The Early Site Suitability Evaluation and
iterative performance assessments provide
status and priorities to the site program**

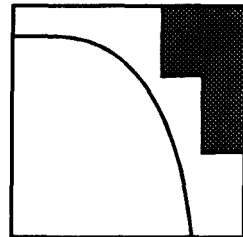
Site-Specific Technical Issues Identified by the Early Site Suitability Evaluation



Role and magnitude of future climate change



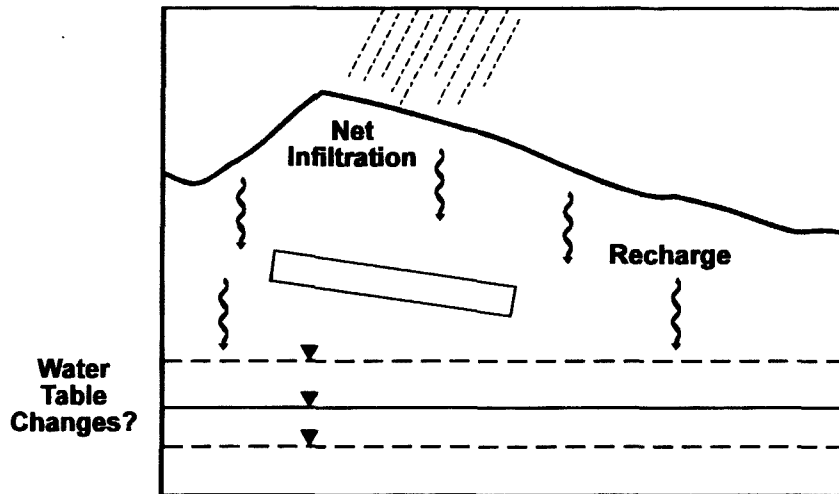
Effects of climatic changes on surface and subsurface geohydrologic systems



Consequences for waste isolation

Technical vs. Regulatory View of the Issue

Technical Objectives



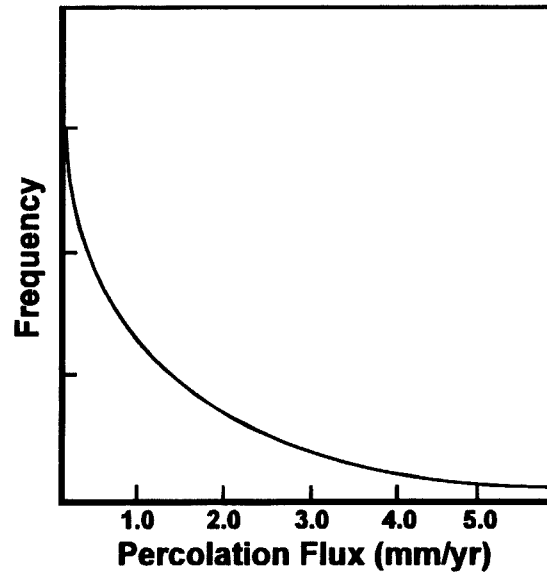
Regulatory Objectives

Ground-water travel time
Waste package performance
Engineered barrier system releases
Total system releases

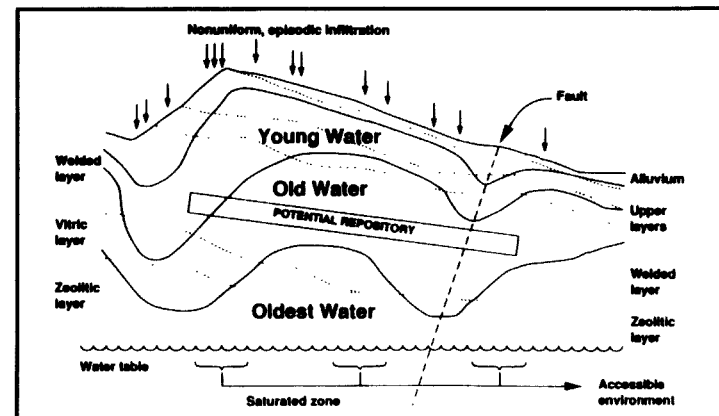
Performance Assessment Provides the Link Between Technical and Regulatory Objectives

- **Determines appropriate abstractions with site experts**
- **Develops and exercises abstracted models and codes**
- **Identifies sensitive site parameters for data acquisition**
- **Refines models and codes on basis of improved understanding**
- **Provides improved basis for regulatory evaluations**

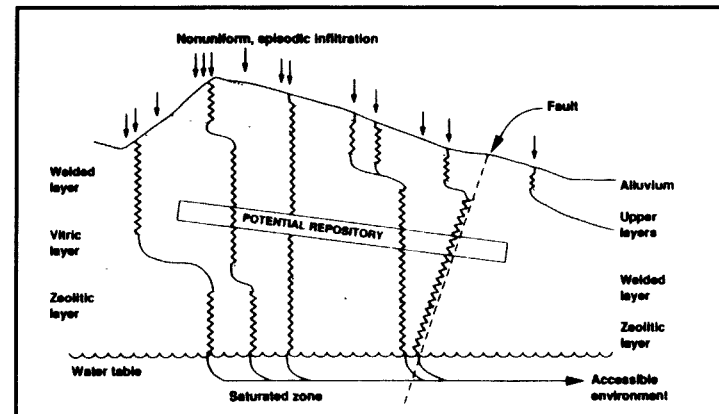
Performance Assessment Determines Appropriate Abstractions for Subsystem and System Models by Negotiating with Site Experts



Composite Model

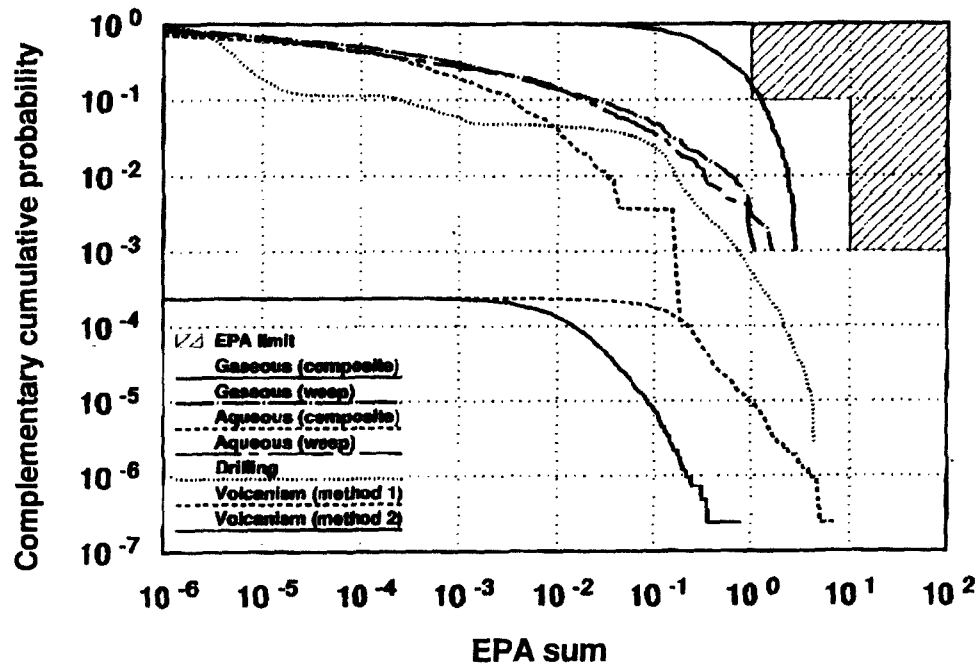


Weeps Model



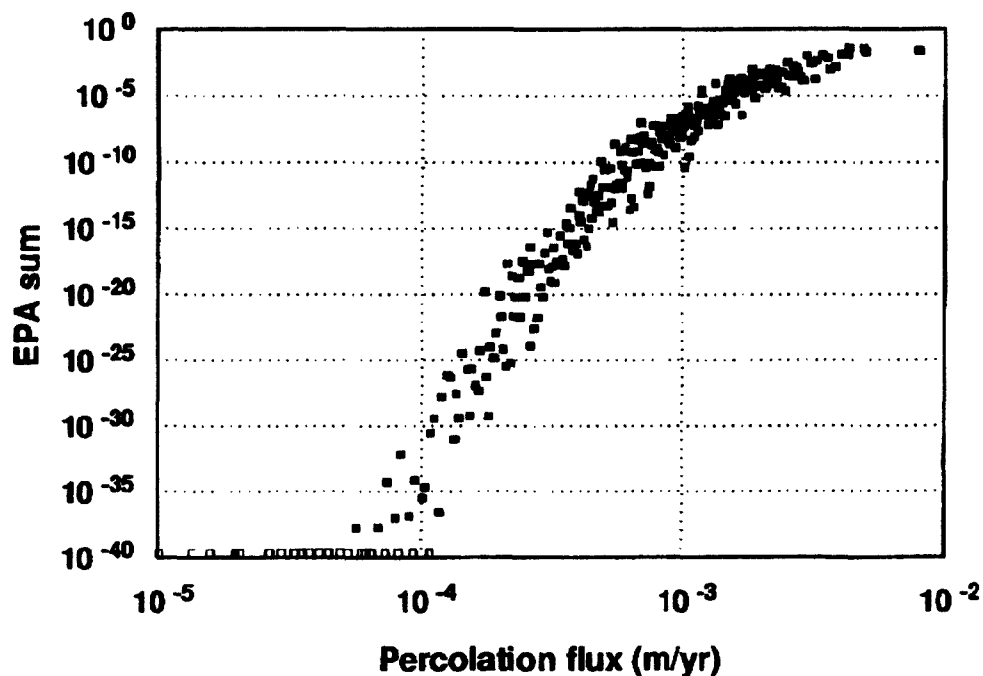
Performance Assessment Develops and Exercises Codes Based on Abstractions of Site Processes and Conditions

Conditional CCDFs for TSPA (SNL, 1991)



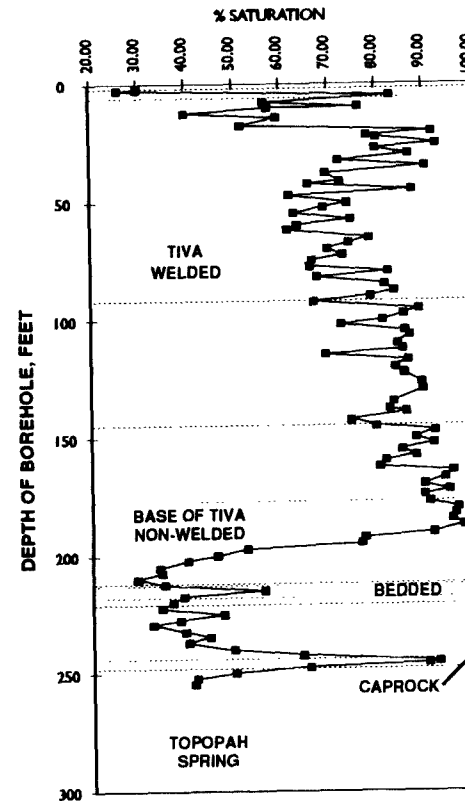
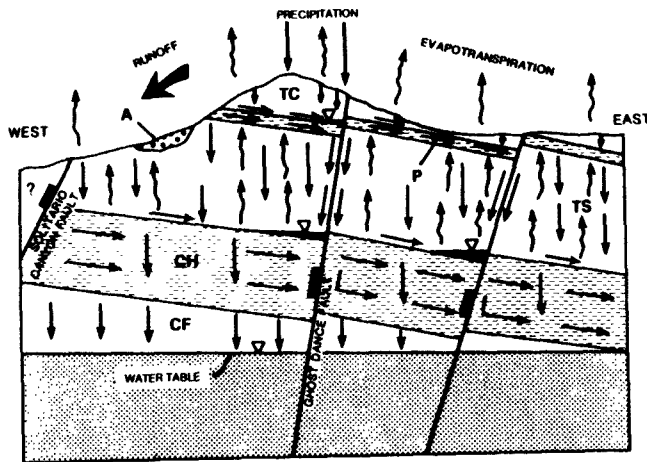
Performance Assessment Identifies Sensitive Site Parameters and Provides Basis for Prioritizing Data Acquisition

Aqueous Releases
Composite-porosity model

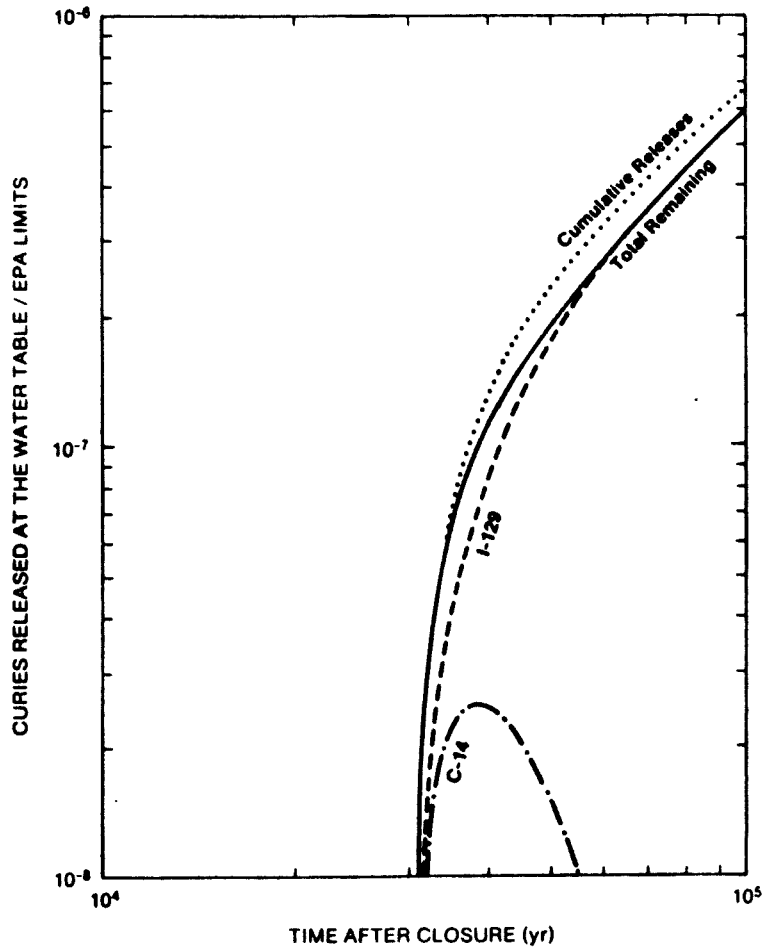


Performance Assessment Refines Models and Codes on the Basis of Improved Understanding of Site Conditions and Processes

Unsaturated Zone,
Conceptual model of flow

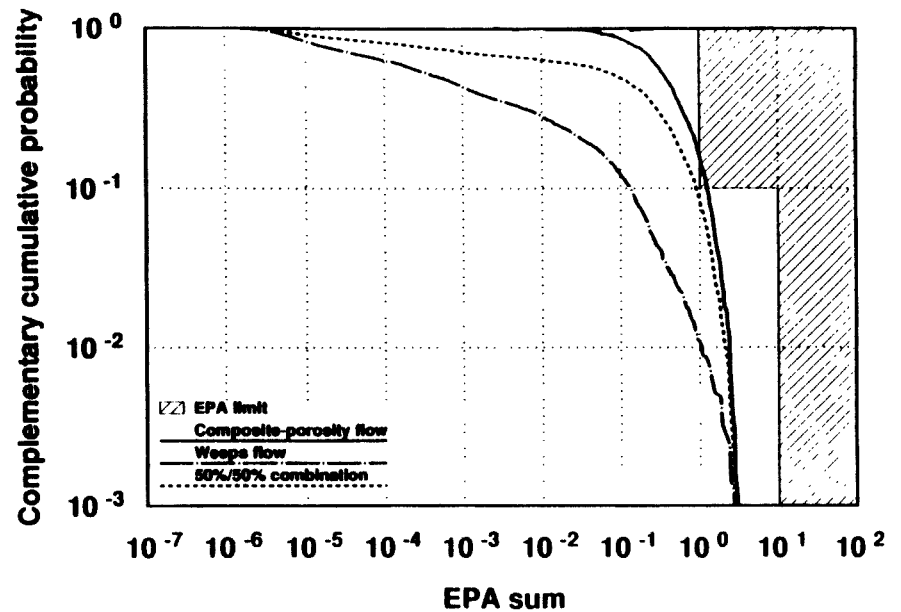


Performance Assessment Provides an Improved Basis for Evaluating Status Against Regulatory Objectives

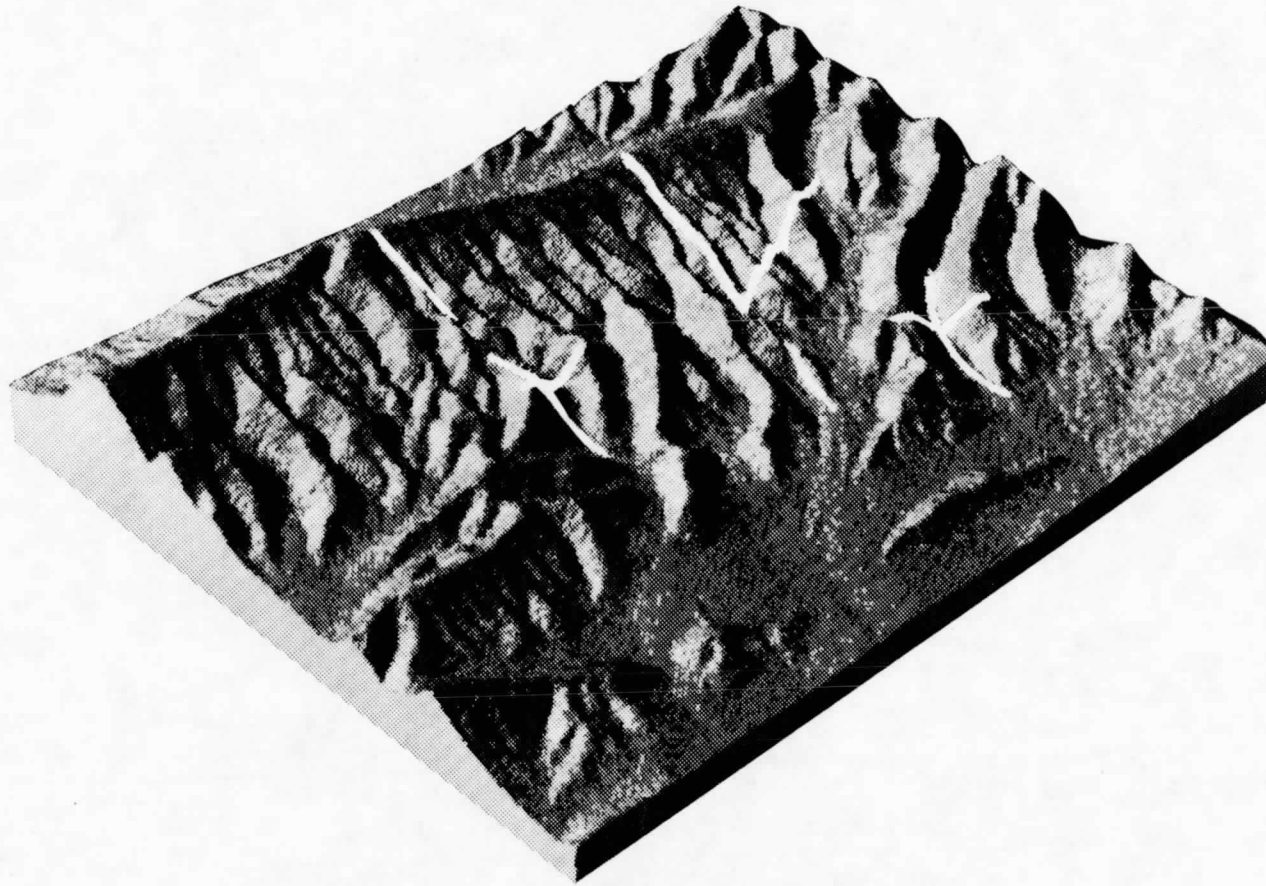


Sinnock, Lin and Brannen, 1984

Overall Conditional CCDF, with Three Weightings of Composite-Porosity and Weeps Models

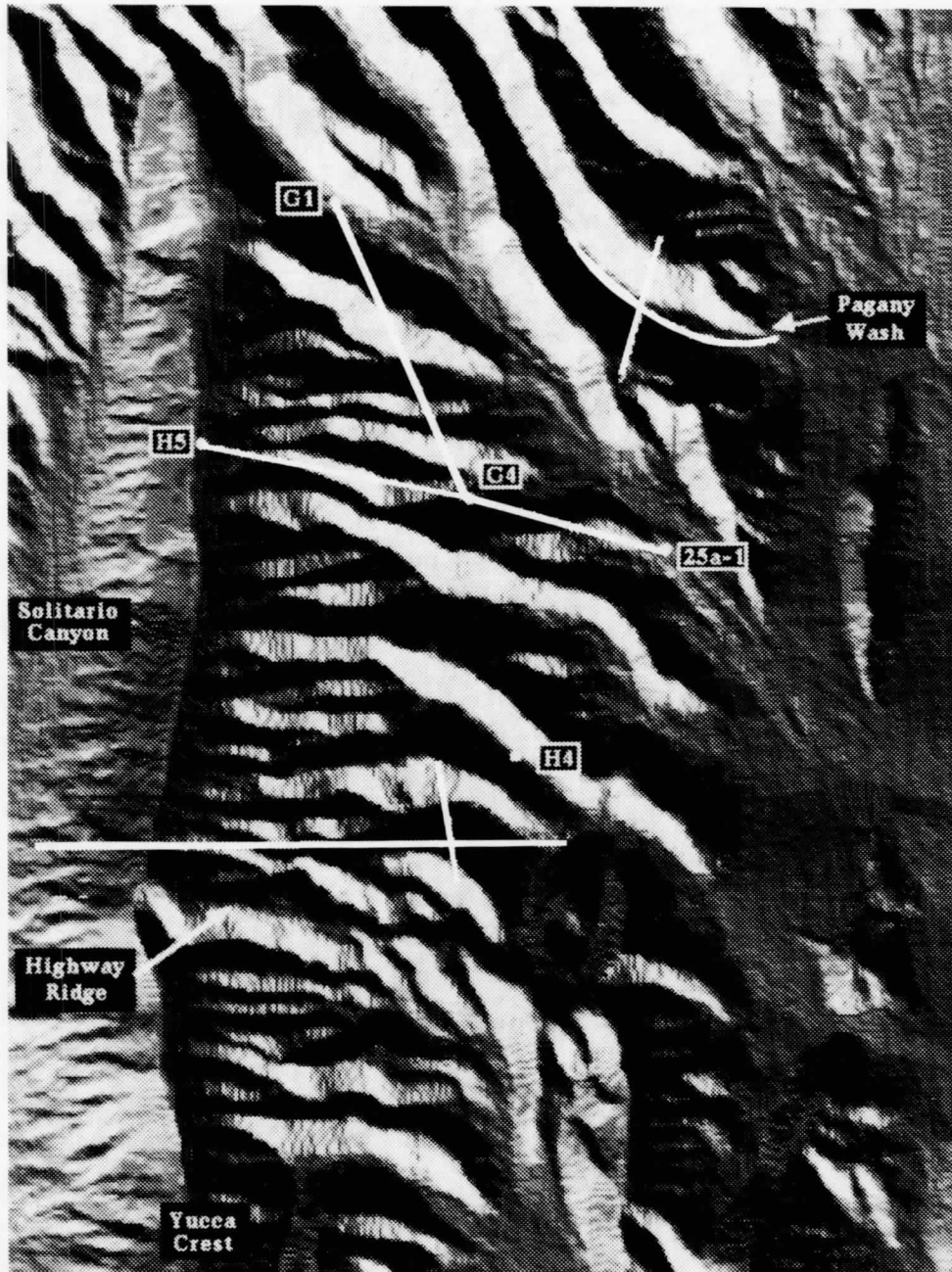


Potential Cross-Sections for Boundary Conditions Studies at Yucca mountain



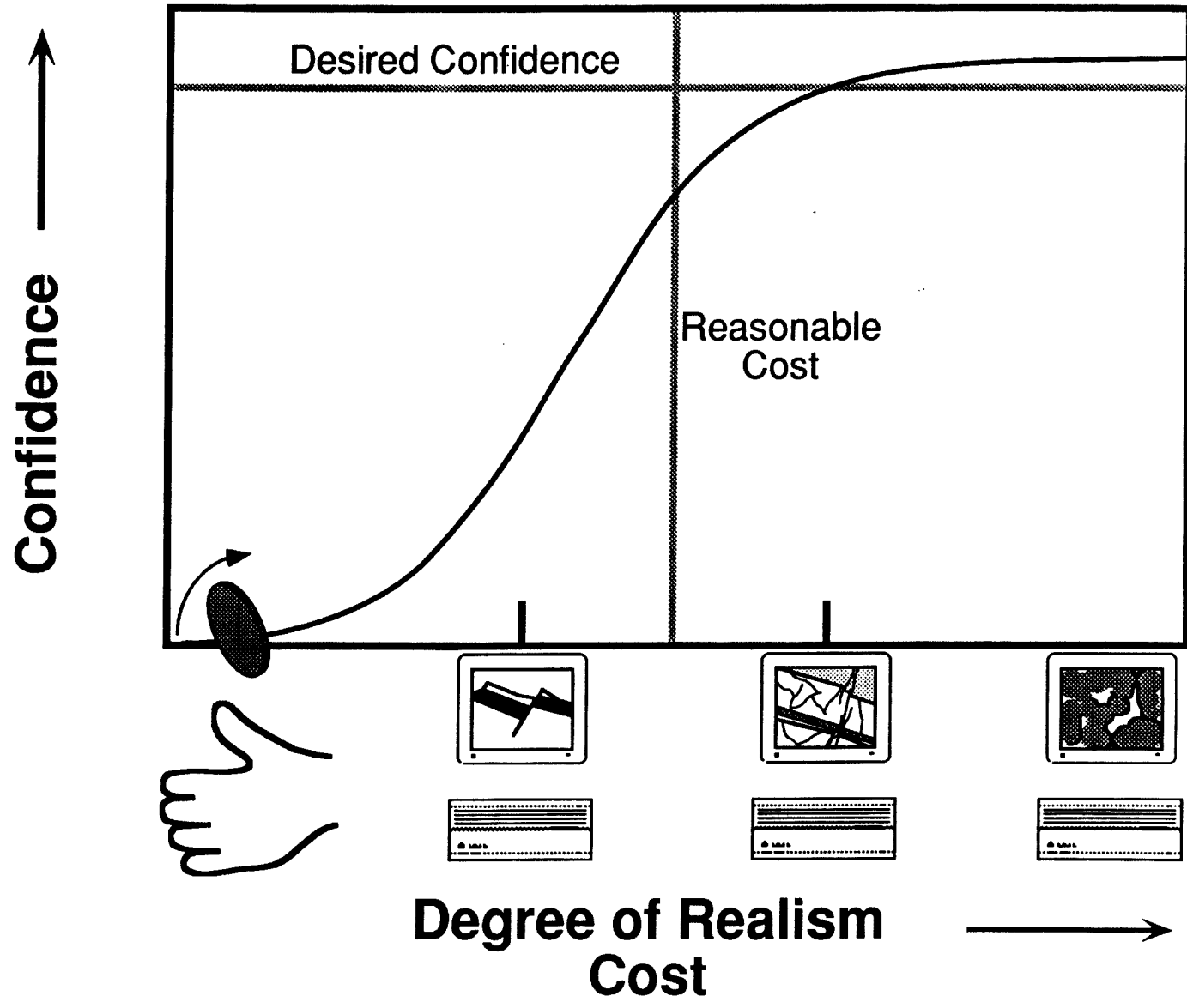
Relief map of Topopah SW 7.5 Minute Quadrangle
Viewing angle from the Southeast
Lighting angle from the Southwest

Potential Cross-Sections for Boundary Conditions Studies at Yucca Mountain

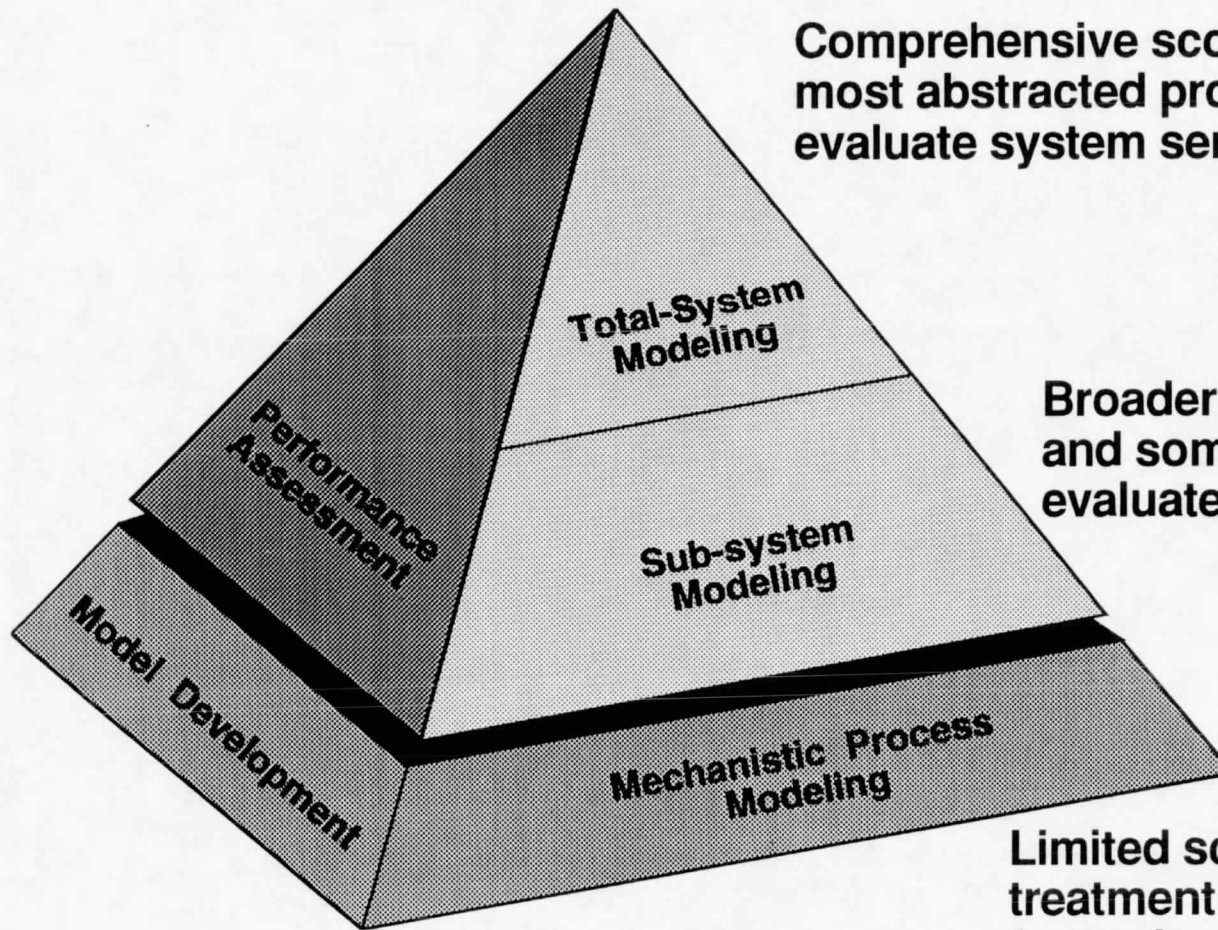


Relief map of Topopah SW 7.5 Minute Quadrangle
Lighting angle from the Southwest

Basis for Management Decisions about Priorities



Abstraction of Critical Features of Performance



Comprehensive scope, stochastic input, most abstracted process simulation, evaluate system sensitivities

Broader scope, partial abstraction, and some coupling of processes, evaluate critical processes

Limited scope, comprehensive treatment of modeled process, for understanding phenomena