

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

**PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT: LINKAGE FROM PERFORMANCE
ASSESSMENT TO THE SITE
PROGRAM**

PRESENTER: MAXWELL B. BLANCHARD

**PRESENTER'S TITLE
AND ORGANIZATION: DIRECTOR, REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN PROJECT OFFICE
U.S. DEPARTMENT OF ENERGY**

**PRESENTER'S
TELEPHONE NUMBER: (702) 794-7939**

MAY 16-17, 1989

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

**PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT: LINKAGE FROM PERFORMANCE
ASSESSMENT TO THE SITE
PROGRAM**

PRESENTER: MAXWELL B. BLANCHARD

**PRESENTER'S TITLE
AND ORGANIZATION: DIRECTOR, REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN PROJECT OFFICE
U.S. DEPARTMENT OF ENERGY**

**PRESENTER'S
TELEPHONE NUMBER: (702) 794-7939**

MAY 16-17, 1989

SCOPE OF PRESENTATION

- **OVERVIEW OF PURPOSES OF SITE CHARACTERIZATION**
- **APPROACH FOR REDUCING UNCERTAINTY IN CONCEPTUALIZATION OF PHYSICAL SYSTEM**
- **EXAMPLES OF HYPOTHESIS TESTING TABLES FROM THE SITE CHARACTERIZATION PLAN**

APPROACHES TO REDUCING UNCERTAINTIES IN THE SITE PROGRAM

- **THE GOAL OF THE SITE PROGRAM IS TO IMPROVE CURRENT UNDERSTANDING OF THE NATURE AND RATES OF GEOLOGIC PROCESSES OPERATING AT THE YUCCA MOUNTAIN SITE THAT MAY IMPACT CONTAINMENT AND ISOLATION**
 - **REDUCE UNCERTAINTY IN SITE PARAMETERS**
 - **REDUCE UNCERTAINTY IN CONCEPTUALIZATION OF SITE PHYSICAL SYSTEM**

APPROACHES TO REDUCE UNCERTAINTY IN UNDERSTANDING THE SITE

MINIMIZE UNCERTAINTY IN SITE PARAMETER VALUES IMPORTANT TO WASTE ISOLATION

- **USE MULTIPLE APPROACHES TO OBTAIN PARAMETERS (E.G. WATER INFILTRATION: CONDUCT TEST FOR NATURAL INFILTRATION, CONTROLLED ^{IN}FILTRATION, PROPERTIES OF SURFICIAL MATERIALS)**
- **MAKE MEASUREMENTS AT DIFFERENT SCALES (E.G. FRACTURE HYDROLOGIC PROPERTIES IN UNSATURATED ZONE: SINGLE FRACTURE, FRACTURE NETWORK)**

APPROACHES TO REDUCE UNCERTAINTY IN UNDERSTANDING THE SITE

CONTINUED

CURRENT PLANS CONTAIN

- **SURFACE-BASED DRILLING PROGRAM (STATISTICAL & FEATURES; MONITORING; CORE RETRIEVAL)**
- **IN SITU TESTING IN THE EXPLORATORY SHAFT (MAPPING; WASTE PACKAGE ENVIRONMENT; HYDROLOGIC, GEO-CHEMICAL, AND ROCK MECHANICS PARAMETERS)**
- **SURFACE STUDIES (TRENCHING; MAPPING; MONITORING)**
- **LABORATORY STUDIES (BENCH-SCALE; ANALYSIS OF CORE SAMPLES)**

APPROACHES TO REDUCE UNCERTAINTY IN UNDERSTANDING THE SITE

CONTINUED

SOME UNCERTAINTY IS INEVITABLE

- **GEOLOGIC PROPERTIES AND CONDITIONS VARY IN SPACE AND TIME**
- **MEASUREMENTS WILL CONTAIN ERRORS**
- **MANY NATURAL PROCESSES ARE SLOW AND DIFFICULT TO MEASURE**

APPROACH FOR REDUCING UNCERTAINTY IN CONCEPTUALIZATION OF SITE PHYSICAL SYSTEM

- IDENTIFY CURRENT CONCEPTS AND HYPOTHESES
(DERIVED FROM AVAILABLE INFORMATION ABOUT THE SITE)
- SPECIFY UNCERTAINTIES IN CURRENT CONCEPTS AND HYPOTHESES
(QUALITATIVE JUDGEMENTS RELATED TO UNCERTAINTY IN DATA BASE)
- IDENTIFY ALTERNATIVE CONCEPTS AND HYPOTHESES
(LOW UNCERTAINTY IN CURRENT HYPOTHESES MAY RESULT IN NO ALTERNATIVES)
- ESTABLISH NEED TO REDUCE UNCERTAINTY IN CURRENT OR ALTERNATIVE HYPOTHESIS BY LINKING TO PERFORMANCE REQUIREMENTS AND DETERMINING SENSITIVITY (I.E. COULD ALTERNATIVES NEGATIVELY IMPACT PERFORMANCE?)
- COLLECT INFORMATION TO DISCRIMINATE AMONG COMPETING HYPOTHESES OR REDUCE UNCERTAINTY IN CURRENT HYPOTHESIS

or improve?

FUNDAMENTAL QUESTIONS ABOUT SITE PERFORMANCE THAT RELY ON CREDIBLE CONCEPTUAL MODELS

● **GEOLOGIC**

- **WHAT IS THE PROBABILITY THAT BASALTIC MAGMA WILL PENETRATE THE REPOSITORY OVER THE NEXT 10,000 YEARS?**
- **WHAT RANGE OF CHANGES IN THE WATER TABLE CAN BE INDUCED BY FUTURE TECTONIC EVENTS?**
- **HOW LIKELY IS FAULT MOVEMENT THAT COULD BREACH AN INDIVIDUAL WASTE PACKAGE?**

● **HYDROLOGIC**

- **WHAT IS THE MOISTURE FLUX THROUGH THE REPOSITORY HORIZON?**
- **IS THE UNSATURATED-ZONE MOISTURE MOVEMENT PREDOMINANTLY IN THE MATRIX OR IN BOTH MATRIX AND FRACTURES?**
- **WHAT IS THE RATE AND DIRECTION OF GROUND-WATER MOVEMENT FROM THE REPOSITORY HORIZON TO THE ACCESSIBLE ENVIRONMENT?**

FUNDAMENTAL QUESTIONS ABOUT THE SITE PERFORMANCE THAT RELY ON CREDIBLE CONCEPTUAL MODELS

(CONTINUED)

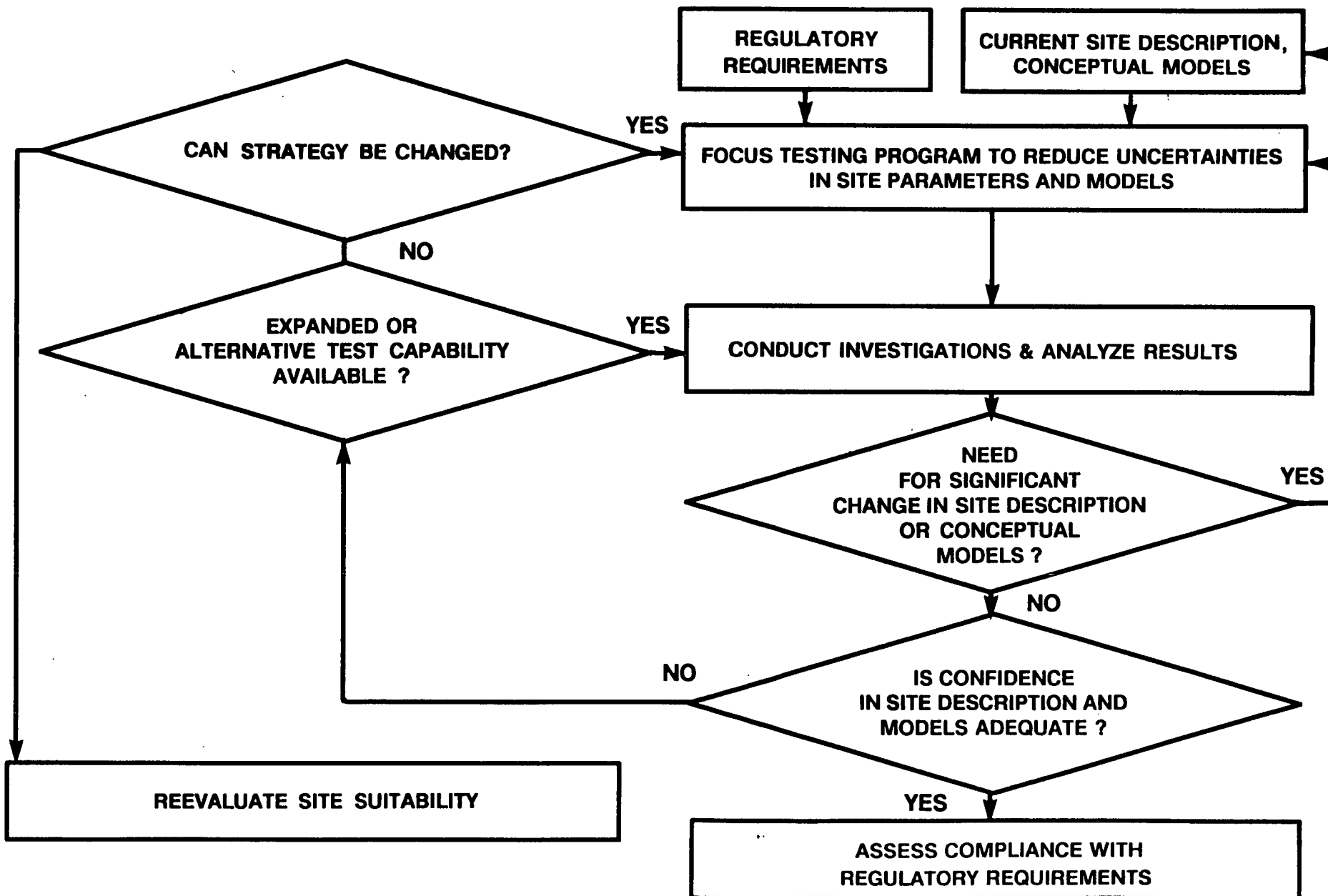
● GEOCHEMICAL

- WHAT IS THE QUANTITY AND DISTRIBUTION OF SORPTIVE MINERALS ALONG FLOW PATHS?**
- HOW WILL THE LABORATORY RESULTS ON MATRIX DIFFUSION AND RETARDATION BE RELIABLY TRANSLATED TO FIELD CONDITIONS?**

● CLIMATE

- HOW DO WE DETERMINE THE BOUNDS ON FUTURE CLIMATE CONDITIONS?**
- WHAT WILL THE IMPACT OF FUTURE CLIMATE CHANGES BE ON UNSATURATED-ZONE FLUX AND FLOW MECHANISMS?**

STRATEGY FOR THE CONDUCT OF THE SITE PROGRAM



SITE PROGRAMS**# OF ALTERNATE
CONCEPTS AND
HYPOTHESES**

GEOHYDROLOGY	73
GEOCHEMISTRY	22
ROCK CHARACTERISTICS	17
CLIMATE	28
HUMAN INTERFERENCE	6
THERMAL AND MECHANICAL ROCK PROPERTIES	8
PRECLOSURE AND POSTCLOSURE TECTONICS	56

EXAMPLE OF CONDENSED HYPOTHESIS TESTING TABLE

PRECLOSURE TECTONICS

(SCP SECTION 8.3.1.8)

1		2		3		4			5
Current representation		Uncertainty and rationale		Alternative hypothesis		Significance of alternative hypothesis			Studies or activities to reduce uncertainty
Model element	Current representation				Performance measure design or performance parameter	Needed confidence in parameter or performance measure	Sensitivity of parameter or performance measure to hypothesis	Need to reduce uncertainty	
Faulting geometry and mechanisms	No hypothesis selected (one or more alternative hypotheses may apply to domain)	High--no data on on subsurface geometry of local faults, no measurements of strike-slip component of movement	Faults in the domain are: Planar-rotational	Design-basis ground-motion time histories and corresponding response spectra for facilities important to safety	Medium to high	High--local fault geometries could significantly affect ground-motion and fault slip estimates	High	Reflection and refraction surveys	
			Detachment	Potential for vibratory ground motion at facilities important to safety	Medium to high	Same as above	High	Age and recurrence intervals on Quaternary faults	
			Part of Walker Lane system	Probability of faulting with displacements over 5 cm in repository and at location of facilities important to safety	Medium to high	Same as above	High	Quaternary faulting near the site within NE-trending zone	
		Related to a strike-slip fault concealed beneath a detached upper plate						Detachment faults at or near Yucca Mountain	
		Normal faults resulting from thermally-driven processes						Monitoring current seismicity	
								3-Dimensional geologic model of site area	

HYPOTHESIS TABLE EXAMPLE PRECLOSURE TECTONICS

**COLUMN 1: CURRENT REPRESENTATION
(CONCEPT OR HYPOTHESIS)**

LOCAL FAULTING GEOMETRY & MECHANISMS

**NO HYPOTHESIS SELECTED
(1 OR MORE ALTERNATIVES MAY APPLY)**

COLUMN 2: UNCERTAINTY

**HIGH: LIMITED DATA ON SUBSURFACE
GEOMETRY OF LOCAL FAULTS; NO
MEASUREMENTS OF STRIKE-SLIP
MOVEMENT**

HYPOTHESIS TABLE EXAMPLE PRECLOSURE TECTONICS

(CONTINUED)

COLUMN 3: ALTERNATIVE HYPOTHESES

PLANAR ROTATIONAL FAULT MODEL

DETACHMENT FAULTS

**LOCAL FAULTS ARE PART OF THE WALKER-LANE
SYSTEM**

**LOCAL FAULTS ARE RELATED TO A STRIKE-SLIP
FAULT CONCEALED BENEATH A DETACHED
UPPER FAULT PLATE**

**LOCAL FAULTS ARE NORMAL FAULTS RESULTING
FROM INCIPIENT RIFTING ALONG THE DEATH
VALLEY-PANCAKE RANGE ZONE DUE TO
THERMALLY DRIVEN PROCESSES**

HYPOTHESIS TABLE EXAMPLE PRECLOSURE TECTONICS

(CONTINUED)

COLUMN 4: SIGNIFICANCE OF ALTERNATIVE HYPOTHESIS

- **PERFORMANCE MEASURES AFFECTED**
 - DESIGN BASIS GROUND MOTION
 - RESPONSE SPECTRA
 - PROBABILITY OF >5cm DISPLACEMENTS

- **CONFIDENCE NEEDED IN PERFORMANCE MEASURE**
 - MEDIUM TO HIGH

- **SENSITIVITY TO HYPOTHESIS**
 - HIGH – LOCAL FAULT GEOMETRIES COULD SIGNIFICANTLY AFFECT GROUND MOTION AND FAULT SLIP ESTIMATES

- **NEED TO REDUCE UNCERTAINTY**
 - HIGH

HYPOTHESIS TABLE EXAMPLE PRECLOSURE TECTONICS

(CONTINUED)

COLUMN 5: STUDIES OR ACTIVITIES TO REDUCE UNCERTAINTY

INTERMEDIATE DEPTH REFLECTION AND REFRACTION

**AGE AND RECURRENCE OF MOVEMENT ON
QUATERNARY FAULTS**

**QUATERNARY FAULTING NEAR THE SITE WITHIN
NE-TRENDING FAULT ZONES**

DETACHMENT FAULTS AT OR NEAR YUCCA MOUNTAIN

MONITORING CURRENT SEISMICITY

3-DIMENSIONAL GEOLOGIC MODEL OF SITE AREA

EXAMPLE OF HYPOTHESIS TESTING TABLE GEOCHEMISTRY (SCP SECTION 8.3.1.3, TABLE 8.3.1.3-2)

1		2	3	4			5	
<u>Current representation</u>		<u>Uncertainty in current understanding</u>	<u>Alternative hypothesis and significance</u>					<u>Tests to distinguish hypothesis and reduce uncertainty</u>
Model element	Current representation	Uncertainty and rationale	Alternative hypothesis	Performance measure design or performance parameter	Needed confidence in parameter or performance measure	Sensitivity of parameter or performance measure to hypothesis	Need to reduce uncertainty	Studies or activities to reduce uncertainty
Mineral stability	Secondary mineralogy along flow paths (particularly sorptive minerals) will remain stable under post-emplacment conditions or, at least, their alteration is predictable based on thermodynamic considerations	Medium--thermodynamic data are not extensive and low temperature alteration processes are difficult to quantify experimentally	Alteration rates are controlled by local conditions (interfaced processes) and are too complex to model reliably	Retardation factor	High	High	Low--alternate hypothesis not supported by existing data	8.3.1.3.3--stability of minerals and glasses

HYPOTHESIS TABLE EXAMPLE GEOCHEMISTRY

COLUMN 1: CURRENT REPRESENTATION (CONCEPT OR HYPOTHESIS)

MINERAL STABILITY

MINERALS ARE STABLE

**ALTERATION OF SECONDARY MINERALS ALONG FLOWPATHS
IS PREDICTABLE**

COLUMN 2: UNCERTAINTY

**MEDIUM: AVAILABLE THERMODYNAMIC DATA NOT EXTENSIVE
LOW-TEMPERATURE PROCESSES DIFFICULT TO QUANTIFY**

COLUMN 3: ALTERNATIVE HYPOTHESIS

**ALTERATION RATES ARE CONTROLLED BY LOCAL CONDITIONS
AND ARE TOO COMPLEX TO MODEL RELIABLY**

HYPOTHESIS TABLE EXAMPLE GEOCHEMISTRY

CONTINUED

COLUMN 4: SIGNIFICANCE OF ALTERNATIVE HYPOTHESIS

PERFORMANCE MEASURE AFFECTED

- RETARDATION FACTOR**

CONFIDENCE NEEDED IN PERFORMANCE MEASURE

- HIGH**

SENSITIVITY TO HYPOTHESIS

- HIGH**

NEED TO REDUCE UNCERTAINTY

- LOW (ALTERNATE HYPOTHESIS NOT SUPPORTED
BY EXISTING DATA)**

COLUMN 5: STUDIES OR ACTIVITIES TO REDUCE UNCERTAINTY

STABILITY OF MINERALS AND GLASSES

SUMMARY

- **SITE PROGRAM IS BELIEVED TO BE COMPREHENSIVE AND CONTAINS SUFFICIENT REDUNDANCY TO PROVIDE SITE PARAMETERS AT NEEDED LEVELS OF CONFIDENCE FOR PERFORMANCE ASSESSMENTS**
- **THE POTENTIAL FOR ALTERNATIVE CONCEPTS AND HYPOTHESIS HAS BEEN CONSIDERED IN THE PLANS FOR SITE TESTING**
 - **AS NEW SITE INFORMATION IS OBTAINED, THE NUMBER OF ALTERNATIVE CONCEPTS AND HYPOTHESES MAY INITIALLY INCREASE**
 - **WITH ADDITIONAL INFORMATION AND ANALYSES, CERTAIN CONCEPTS AND HYPOTHESES ARE LIKELY TO BE FAVORED**
 - **IN CASES WHERE UNCERTAINTIES REMAIN LARGE AFTER SITE CHARACTERIZATION, BOUNDING ASSUMPTIONS MAY BE NECESSARY**
- **SITE-DERIVED CONCEPTS AND HYPOTHESIS PROVIDE A KEY INTERFACE BETWEEN PERFORMANCE ASSESSMENT AND THE SITE PROGRAM AND ARE EXPECTED TO PROVIDE CONFIDENCE IN PERFORMANCE PREDICTIONS**