

BRIEFING FOR COMMISSIONER CURTISS  
ON HIGH LEVEL WASTE PROGRAMS AT SANDIA LABORATORY

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## HIGH LEVEL WASTE RESEARCH

### OBJECTIVE

- o PROVIDE TECHNICAL BASIS FOR INDEPENDENT ASSESSMENT USED TO LICENSE DOE HLW REPOSITORY

### BASIS FOR PROGRAM

- o LEGISLATIVE MANDATE: NWPA (1982), NWPA (1987)
- o NEW TECHNOLOGY - NO OPERATIONAL EXPERIENCE

### FOCUS

- o PERFORMANCE ASSESSMENT FOR YUCCA MOUNTAIN HYDROGEOLOGY (UNSATURATED, FRACTURED TUFF SETTING)
- o CONFIRMING MATERIALS AND ENGINEERED SYSTEMS PERFORMANCE
- o PROPOSED REVISIONS TO HLW REGS (10 CFR 60)

HIGH-LEVEL WASTE PROGRAM ACTIVITIES

o MATERIALS AND ENGINEERING

- WASTE PACKAGE CORROSION
- SEALING OF BOREHOLES/SHAFTS
- SEISMIC EFFECTS/ROCK MECHANICS

o HYDROLOGY AND GEOCHEMISTRY

- GROUND-WATER FLOW AND TRANSPORT THRU UNSATURATED FRACTURED MEDIA
- NEAR-FIELD GEOCHEMISTRY
- RADIONUCLIDE SORPTION/TRANSPORT

*R* o COMPLIANCE ASSESSMENT AND MODELING

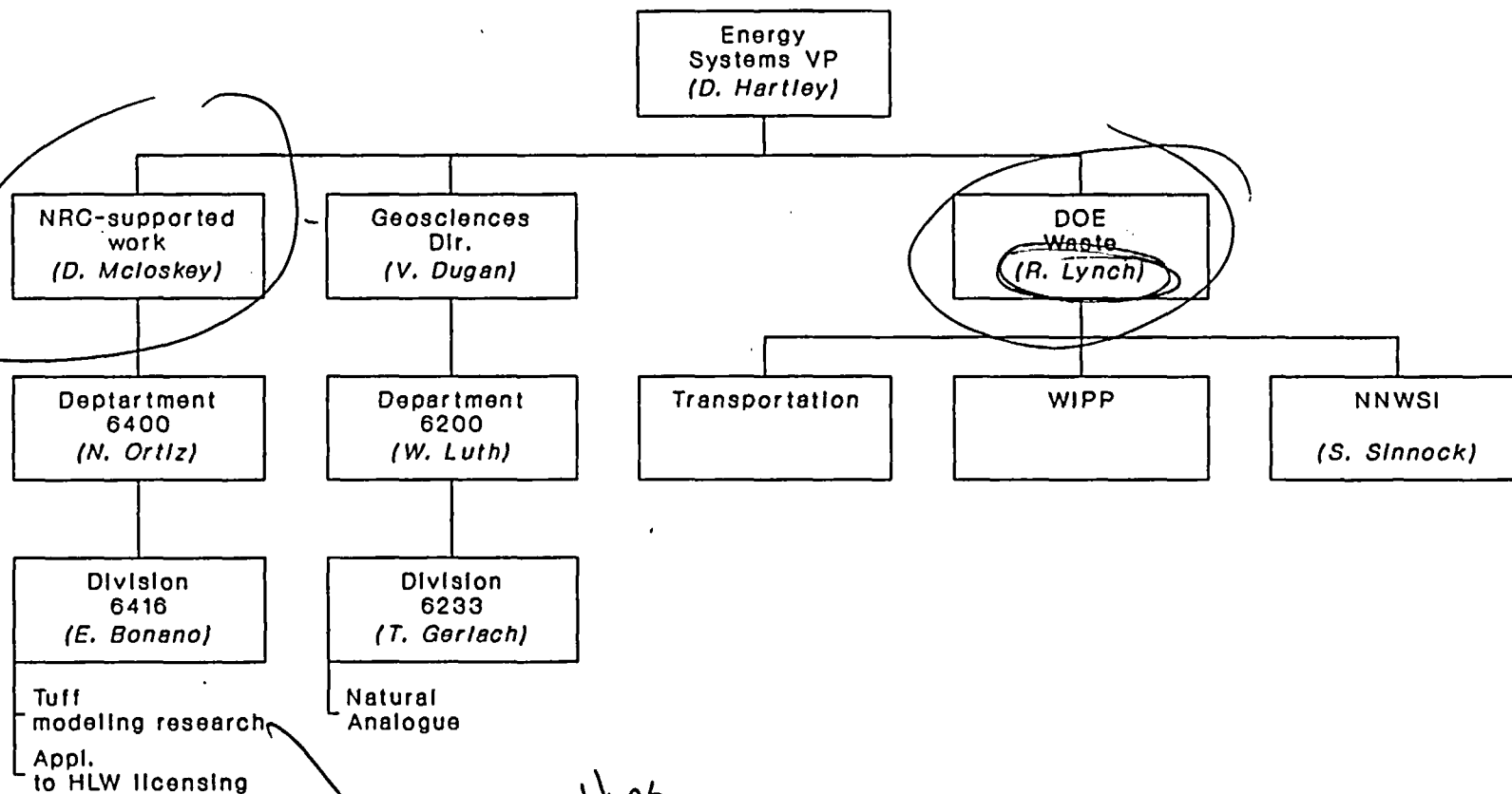
- INDEPENDENT PERFORMANCE ASSESSMENT METHODOLOGY
- VALIDATION: FIELD AND NATURAL ANALOG STUDIES

o SUPPORT OF RULEMAKING

*John Randall*

NRC-SUPPORTED  
HIGH-LEVEL RADIOACTIVE WASTE  
PROJECTS AT  
SANDIA NATIONAL LABORATORIES

# Sandia Waste Management Work Organizational Sturcture



*B1' Super  
replacement*

*Tuff modelling  
research*

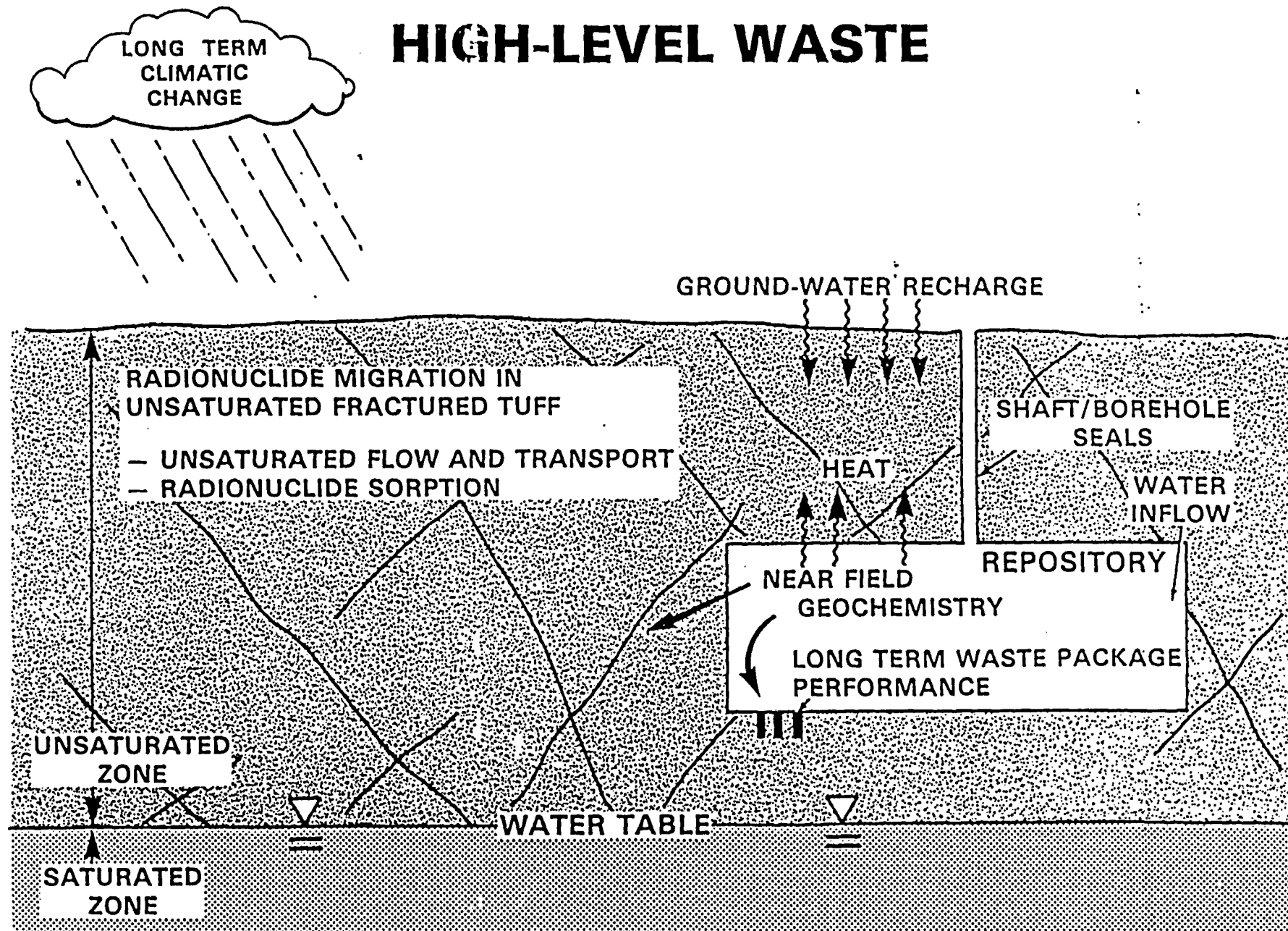
CURRENT NRC-SPONSORED HLW PROJECTS  
AT SNL

- o "DEVELOPMENT OF A METHODOLOGY FOR PERFORMANCE ASSESSMENT OF NUCLEAR WASTE ISOLATION IN ALTERNATIVE GEOLOGIC MEDIA"  
(ALTERNATIVE TO BEDDED SALT, CURRENT EMPHASIS IS ON UNSATURATED WELDED TUFF) (RES)
- o "TECHNICAL ASSISTANCE FOR PERFORMANCE ASSESSMENT" (NMSS)
- o "A NATURAL ANALOGUE FOR A HIGH-LEVEL WASTE REPOSITORY:  
CHEMICAL MIGRATION AND THERMAL EFFECTS IN THE VC-1 COREHOLE,  
VALLES CALDERA, NEW MEXICO" (RES)

## HLW PERFORMANCE ASSESSMENT

THE PROCESS OF QUANTITATIVELY EVALUATING COMPONENT AND SYSTEM BEHAVIOR, RELATIVE TO CONTAINMENT AND ISOLATION OF RADIOACTIVE WASTE, TO SUPPORT DEVELOPMENT OF A REPOSITORY OF HLW AND TO DETERMINE COMPLIANCE WITH THE NUMERICAL CRITERIA ASSOCIATED WITH THE REGULATION 10 CFR 60.

# HIGH-LEVEL WASTE





## *Relationship of Performance Assessment Research to Other NRC HLW Research and Technical Assistance*

### SHORT-TERM TESTS

Site  
Characterization  
(U of Arizona)

Engineered  
Barriers  
(NIST, etc.)

### NRC PERFORMANCE ASSESSMENT

Performance  
Assessment  
Research  
(Sandia)

Application  
of Models to  
HLW Licensing  
(Sandia)

### LONG-TERM APPROACHES

Natural Analogues,  
(Sandia, Australia)

Laboratory  
Simulations  
(CNWRA, Colorado  
State)

International  
Efforts  
(INTRAVAL,  
HYDROCOIN,  
INTRAVAL,  
NEA) *com*

NRC-SUPPORTED HLW PERFORMANCE ASSESSMENT  
RESEARCH AT SANDIA

"DEVELOPMENT OF A METHODOLOGY FOR  
PERFORMANCE ASSESSMENT OF NUCLEAR WASTE  
ISOLATION IN ALTERNATIVE GEOLOGIC MEDIA"

OBJECTIVE: TO MODIFY THE PERFORMANCE ASSESSMENT METHODOLOGIES  
DEVELOPED FOR ISOLATION OF HIGH-LEVEL RADIOACTIVE WASTE IN  
BEDDED SALT AND BASALT SO AS TO OBTAIN A PERFORMANCE  
ASSESSMENT METHODOLOGY THAT IS APPLICABLE TO ISOLATION OF  
HLW IN UNSATURATED WELDED TUFF.

CURRENT TASKS IN THE  
PERFORMANCE ASSESSMENT  
RESEARCH PROJECT

- O METHODOLOGY DEVELOPMENT FOR PERFORMANCE ASSESSMENT OF  
RADIOACTIVE WASTE ISOLATION IN WELDED TUFF
- O CALCULATIONS IN SUPPORT OF INTRAVAL

STATUS OF PERFORMANCE ASSESSMENT  
RESEARCH PROJECT

TUFF METHODOLOGY TASK

- O A COMPARISON OF THE CHARACTERISTICS OF BEDDED SALT, BASALT, AND TUFF (COMPLETE; LETTER REPORT)
- O A COMPARISON OF COMPUTER PROGRAMS THAT IMPLEMENT MATHEMATICAL MODELS OF WATER MOVEMENT IN UNSATURATED MEDIA (COMPLETE; NUREG/CR, CONFERENCE PAPER)
- O DEVELOPMENT OF RELEASE SCENARIOS FOR THE TUFF METHODOLOGY (COMPLETE; NUREG/CR)
- O FINANCIAL SUPPORT OF AND PARTICIPATION IN THREE WORKSHOPS (CONDUCTED IN 1982, 1984, AND 1986 IN COOPERATION WITH THE UNIVERSITY OF ARIZONA) ON THE FLOW OF GROUNDWATER AND TRANSPORT OF RADIONUCLIDES IN UNSATURATED TUFF (COMPLETE; TRIP REPORTS CONTAINING WORKSHOP DOCUMENTS)
- O AN ANALYSIS OF VAPOR PHASE TRANSPORT IN UNSATURATED TUFF (COMPLETE; NUREG/CR)
- O INVESTIGATION OF PERTURBATIONS TO LIQUID/VAPOR EQUILIBRIA IN UNSATURATED WELDED TUFF (50% COMPLETE; NUREG/CR, JOURNAL ARTICLE, 9/89)
- O DEVELOPMENT OR MODIFICATION OF COMPUTER PROGRAM FOR SIMULATING GROUNDWATER FLOW IN UNSATURATED TUFF (50% COMPLETE)
- O ANALYSIS OF GROUNDWATER TRAVEL TIME IN UNSATURATED TUFF (50% COMPLETE; LETTER REPORTS, 3/89 AND 9/89)

- 0 INTEGRATION OF RESULTS OF PREVIOUS SUBTASKS LISTED HERE AND TECHNOLOGY TRANSFER TO THE NRC STAFF AND NRC'S CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES (CNWRA) (JUST STARTED; LETTER REPORT (12/88), NUREG/CR (9/90))

21 Issues:

~~too~~ Water -  $\rightarrow$  Heat pipe  
 $\rightarrow$  Recharge

DOE's position - based on an average reduction -

Q - What about intermittent recharge? — one good thing.

## INTRAVAL TASK

O SOLUTION OF INTRAVAL PROBLEMS (33.3% COMPLETE)

- 1) THE APACHE LEAP TUFF SITE (FROM FIN D1662).
- 2) THE BOREHOLE EXPERIMENT IN G-TUNNEL AT THE NEVADA TEST SITE.
- 3) THE LAS CRUCES TRENCH STUDY (FROM FIN B5694).

O TECHNOLOGY TRANSFER (10% COMPLETE) <

NRC-SUPPORTED HLW PERFORMANCE ASSESSMENT  
TECHNICAL ASSISTANCE AT SANDIA

"TECHNICAL ASSISTANCE FOR PERFORMANCE ASSESSMENT"

OBJECTIVE: TO PROVIDE TECHNICAL ASSISTANCE TO NRC ON HLW PERFORMANCE ASSESSMENT ISSUES RELATED TO REVIEWING DOE'S SITE CHARACTERIZATION PLANS, PROVIDING PRE-LICENSING GUIDANCE TO DOE, IDENTIFYING NEEDED NRC RESEARCH FOR MODELING PROCESSES THAT MAY AFFECT HLW REPOSITORY PERFORMANCE, AND REVIEWING DOE'S APPLICATION FOR HLW DISPOSAL.

CURRENT TASKS IN THE  
PERFORMANCE ASSESSMENT  
TECHNICAL ASSISTANCE PROJECT

- O PROVIDING TECHNICAL ASSISTANCE TO THE NRC IN THE EVALUATION AND IMPLEMENTATION OF A LICENSING ASSESSMENT METHODOLOGY
- O IDENTIFICATION AND ANALYSIS OF UNCERTAINTIES ASSOCIATED WITH HLW REPOSITORY PERFORMANCE ASSESSMENTS
- O IDENTIFYING AND ANALYZING QUANTITATIVE TECHNIQUES FOR ASSIGNING PROBABILITIES OF OCCURRENCE TO POTENTIALLY DISRUPTIVE EVENTS AND PROCESSES
- O MAINTENANCE AND CONFIGURATION MANAGEMENT OF PERFORMANCE ASSESSMENT COMPUTER CODES

NMSS wants Smiden to  
collect all of its  
thoughts on performance  
assessments —



STATUS OF PERFORMANCE ASSESSMENT  
TECHNICAL ASSISTANCE PROJECT

LICENSING ASSESSMENT METHODOLOGY

- O IDENTIFICATION OF TECHNICAL COMPONENTS OF PERFORMANCE  
ASSESSMENT METHODOLOGY (COMPLETE; LETTER REPORT, NUREG/CR  
(EXISTS AS DRAFT))
- O ASSEMBLY OF COMPUTER PROGRAMS THAT IMPLEMENT MATHEMATICAL  
MODELS RELATED TO EACH TECHNICAL COMPONENT OF PERFORMANCE  
ASSESSMENT (60% COMPLETE; NUREG/CR (4/89))
- O RECOMMENDATION OF A TECHNICAL BASIS FOR NRC REVIEW OF DOE'S HLW  
MODELING PROGRAM (60% COMPLETE; LETTER REPORTS (9/88, 11/88,  
1/89), NUREG/CR (5/89))

## UNCERTAINTIES TASK

- O TECHNIQUES FOR IMPLEMENTATION OF EPA'S HLW STANDARD (40 CFR 191) (90% COMPLETE; NUREG/CR (12/88))
- O IDENTIFICATION OF SOURCES OF UNCERTAINTY; TECHNIQUES FOR QUANTIFYING AND REDUCING UNCERTAINTY IN HLW PERFORMANCE ASSESSMENTS (COMPLETE; NUREG/CR (DRAFT))
- O USE OF EXPERT JUDGMENT IN DEALING WITH UNCERTAINTIES IN HLW PERFORMANCE ASSESSMENTS (80% COMPLETE; NUREG/CR (1/89))
- O DESCRIPTION OF METHODOLOGIES FOR ANALYZING MODEL UNCERTAINTY (70% COMPLETE; LETTER REPORT (12/89); NUREG/CR (2/89))
- O SCENARIO DEVELOPMENT AND SCREENING (90% COMPLETE; LETTER REPORT (12/88), NUREG/CR (9/88 DRAFT))
- O SOURCES OF DATA AND PARAMETER UNCERTAINTY (35% COMPLETE; LETTER REPORT (8/88), NUREG/CR (8/88 (DRAFT), 6/89, 9/89)

## TASK ON PROBABILITIES OF DISRUPTIVE EVENTS AND PROCESSES

- O LITERATURE REVIEW OF QUANTITATIVE TECHNIQUES FOR ESTIMATING PROBABILITIES OF EVENTS AND PROCESS THAT MAY DISRUPT HLW REPOSITORY PERFORMANCE (COMPLETE; NUREG/CR (6/88 DRAFT))
- O RECOMMENDED TECHNIQUES FOR ESTIMATING PROBABILITIES OF EVENTS AND PROCESS THAT MAY DISRUPT HLW REPOSITORY PERFORMANCE (80% COMPLETE; NUREG/CR (1/89))

## NATURAL ANALOGUES OF HLW DISPOSAL SITES

DEFINITION: A NATURAL OCCURRENCE OF MATERIALS AND/OR PROCESSES THAT ARE ANALOGOUS TO EXPECTED MATERIALS AND/OR PROCESS IN A PROPOSED GEOLOGIC WASTE REPOSITORY. (ADOPTED BY THE NATURAL ANALOGUE WORKING GROUP OF THE COMMISSION OF EUROPEAN COMMUNITIES)

## WHY STUDY NATURAL ANALOGUES?

— Linda  
Kolvaak

- O A GEOLOGIC REPOSITORY OF HLW IS A NATURAL, COMPLEX SYSTEM WITH A VERY LONG OPERATING LIFE.
  - O NRC HAS TO HAVE REASONABLE ASSURANCE THAT PREDICTIONS OF HLW REPOSITORY PERFORMANCE OVER AT LEAST 10,000 YEARS ARE SUFFICIENTLY ACCURATE TO PROVIDE CONFIDENCE IN LICENSING DECISIONS ABOUT HLW DISPOSAL.
    - O LABORATORY EXPERIMENTS OFFER SHORT-TERM TESTS OF SELECTED, ISOLATED PROCESSES.
    - O FIELD EXPERIMENTS OFFER SHORT-TERM TESTS OF COMPLEX PROCESSES.
    - O NATURAL ANALOGUES OFFER LONG-TERM TESTS OF COMPLEX PROCESSES AND ARE THE ONLY AVAILABLE LONG-TERM EXPERIMENTS FOR TESTING MODELS OF HLW REPOSITORY PERFORMANCE.
  - O ADVANTAGES OF NATURAL ANALOGUES ARE:
    - O LONG TIME SCALES
    - O LENGTH SCALES COMPARABLE TO REPOSITORY LENGTH SCALES
    - O RECORDS OF COMPLEX, COUPLED PROCESSES
    - O LONG-TERM AND LARGE-SCALE DATA FOR VALIDATION OF MODELS THAT HAVE BE APPLIED TO LONG TERMS AND LARGE SCALES
    - O CHECKS ON SITE CHARACTERIZATION
- BASIS FOR PUBLIC CONFIDENCE IN MATHEMATICAL MODELS APPLIED

### WHY SHOULD NRC STUDY NATURAL ANALOGUES?

- o 10 CFR 60.21 REQUIRES THAT DOE USE NATURAL ANALOGUES TO SUPPORT PREDICTIONS OF HLW REPOSITORY PERFORMANCE; NRC HAS TO UNDERSTAND WHETHER DOE HAS USED NATURAL ANALOGUES PROPERLY
- o NRC NEEDS ITS OWN BASIS FOR CONFIDENCE IN PERFORMANCE ASSESSMENTS THAT IT USES IN ASSESSING DOE'S LICENSE APPLICATIONS

### WHY STUDY NATURAL ANALOGUES NOW?

- o PROVIDE A BASIS FOR MODEL VALIDATION BEFORE HLW LICENSING DECISIONS HAVE TO BE MADE
- o EARLY RESOLUTION OF PERFORMANCE ISSUES (PRIOR TO LICENSING)

# WHY VALLES CALDERA NATURAL ANALOGUE?

THE VALLES CALDERA NATURAL ANALOGUE IS THE ONLY ONE AVAILABLE TO NRC THAT IS IN UNSATURATED TUFFS THAT ARE IN MANY WAYS SIMILAR TO THE YUCCA MOUNTAIN TUFFS.

N.M.

silica content

NRC is examining  
cores done by  
DOE



NRC-SUPPORTED NATURAL ANALOGUE  
RESEARCH AT SANDIA

"A NATURAL ANALOGUE FOR A HIGH-LEVEL WASTE REPOSITORY:  
CHEMICAL MIGRATION AND THERMAL EFFECTS IN THE VC-1 COREHOLE,  
VALLES CALDERA, NEW MEXICO"

OBJECTIVES: 1) TO TEST ABILITY OF SHORT-TERM LABORATORY  
EXPERIMENTS TO PREDICT OBSERVED MINERALOGICAL ALTERATION IN  
THE VICINITY OF A NATURAL HEAT SOURCE; 2) TO DETERMINE THE  
EXTENT AND MEANS OF ELEMENTAL TRANSPORT IN HEATED ROCK IN  
RESPONSE TO A HEAT SOURCE.

TASKS AND THEIR STATUS IN  
THE NATURAL ANALOGUE PROJECT

O WHOLE ROCK ANALYSES OF MAJOR TRACE ELEMENTS ANALOGOUS TO FISSION PRODUCTS (Na, K, Ca, Al, Si, Fe, H<sub>2</sub>O, Cl IONS, Cs, U, Th, Ta, Sb, Sr, ETC.) (60% COMPLETE; NUREG/CR (6/89))

O CHARACTERIZATION OF ALTERATION PHASES TO ESTABLISH MINERALOGICAL CHANGES (40% COMPLETE; NUREG/CR (1/90))

\* O THERMAL MODELING (CONDUCTION VS CONVECTION) (40% COMPLETE; NUREG/CR (1/91))

O PALEOGEOTHERMS, AGES OF DEPOSITION (ISOTOPIC ARGON AGES TO INDICATE ROCK SOLIDIFICATION TEMPERATURES) (60% COMPLETE; NUREG/CR (6/89))

O EXPERIMENTAL STUDIES (EVALUATION OF SHORT-TERM LABORATORY EXPERIMENTS TO PREDICT LONG-TERM PROCESSES; MOBILIZATION OF TRACE ELEMENTS IN CLOSED, OPEN, AND REFLUX SYSTEMS) (35% COMPLETE; NUREG/CR (9/90))

\* O SYNTHESIS OF RESULTS AND GEOCHEMICAL MODELING (COMBINING RESULTS OF CHEMICAL ANALYSES, OTHER LABORATORY EXPERIMENTS, AND THERMAL MODELING TO OBTAIN A CONSISTENT PICTURE OF THE EVOLUTION OF THE NATURAL ANALOGUE) (30% COMPLETE; NUREG/CR (1/91))

DOE & NRC are  
weak in this  
area.

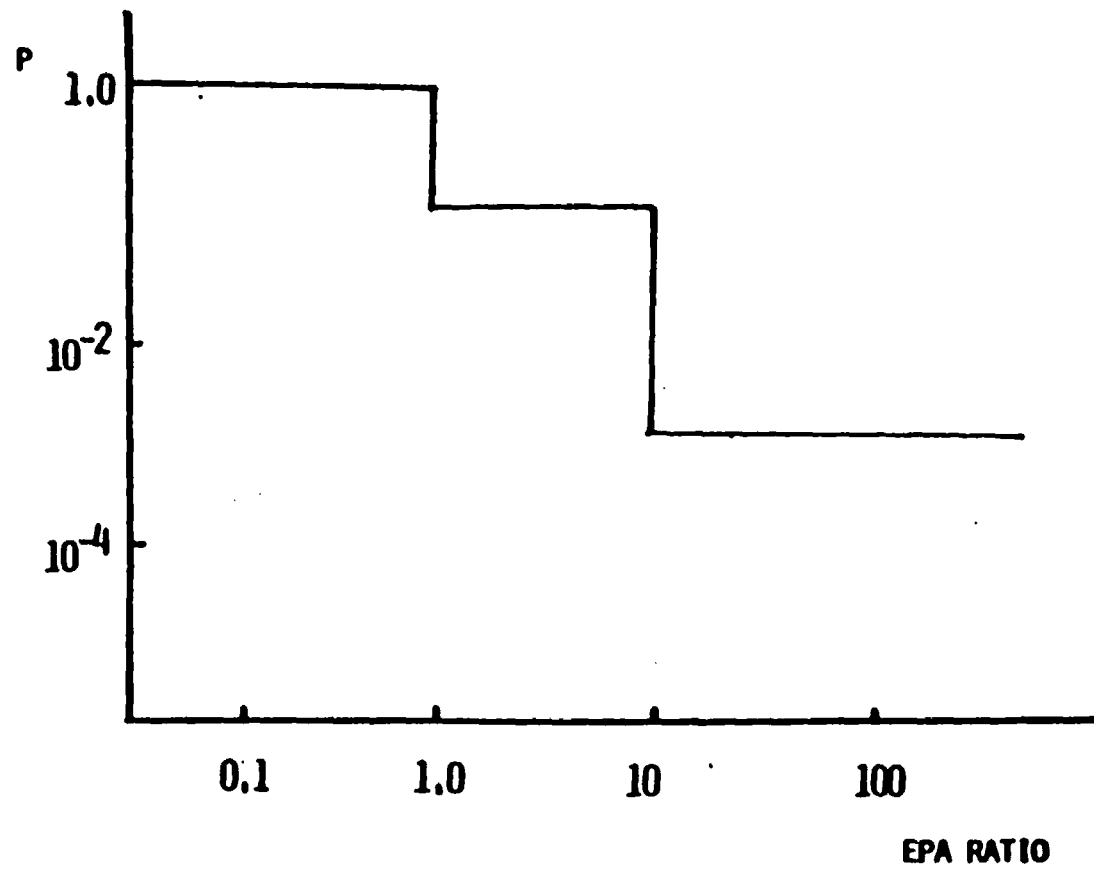
EPA STANDARD

ACRS BRIEFING: 10/24/85

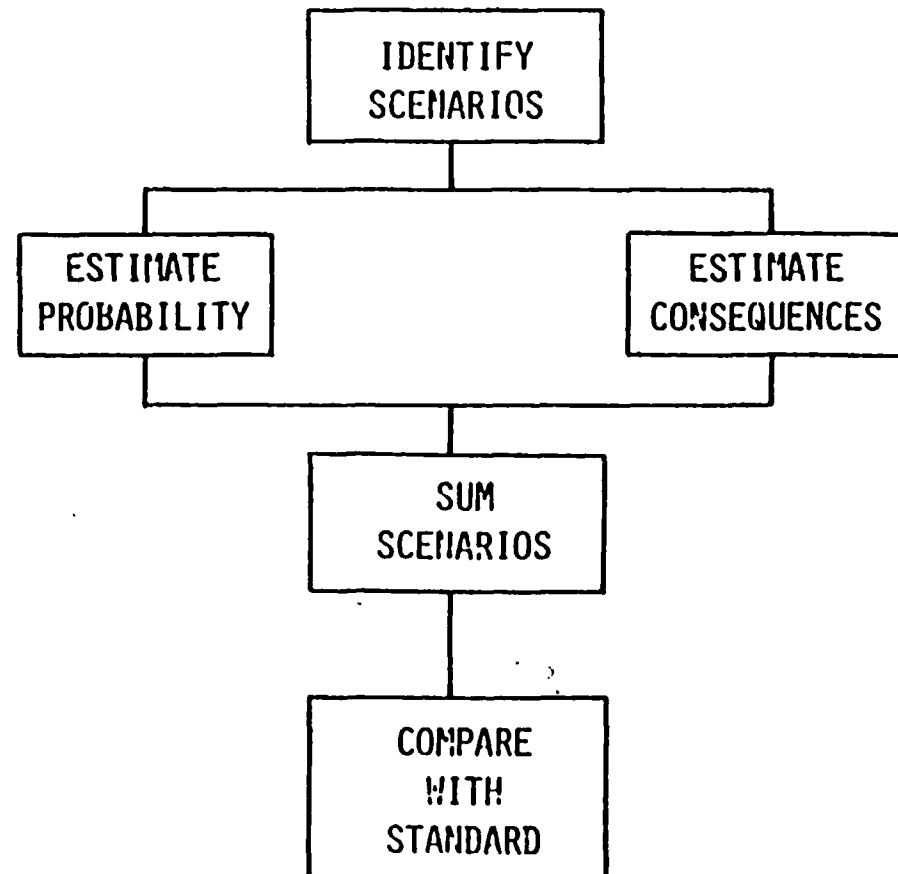
EPA STANDARD

- o EMPLACEMENT OPERATIONS
- o POST EMPLACEMENT
  - LIMITS RELEASE TO "ACCESSIBLE ENVIRONMENT"
  - RELEASE - TOTAL CURIES OVER 10,000 YEARS
  - NUMERICAL PROBABILITY FEATURE
- o GROUNDWATER PROTECTION REQUIREMENTS
- o INDIVIDUAL PROTECTION REQUIREMENTS

EPA STANDARD



# IMPLEMENTATION OF EPA STANDARD



### IDENTIFY SCENARIOS

- o SCENARIOS ARE SEQUENCES OF EVENTS OR PROCESSES THAT AFFECT THE PERFORMANCE OF A REPOSITORY.
  - EACH SCENARIO IS A POSSIBLE "FUTURE" FOR A REPOSITORY OVER A 10,000 YEAR PERIOD.
  - SCENARIOS ARE MUTUALLY EXCLUSIVE
  - SCENARIOS HAVING PROBABILITY  $< 10^{-4}$  NEED NOT BE CONSIDERED
- o TASK IS MANAGEABLE -- I.E. ONLY A LIMITED NUMBER OF SCENARIOS WILL REQUIRE DETAILED CONSIDERATION

## EXAMPLES OF SCENARIOS

### SCENARIO 1

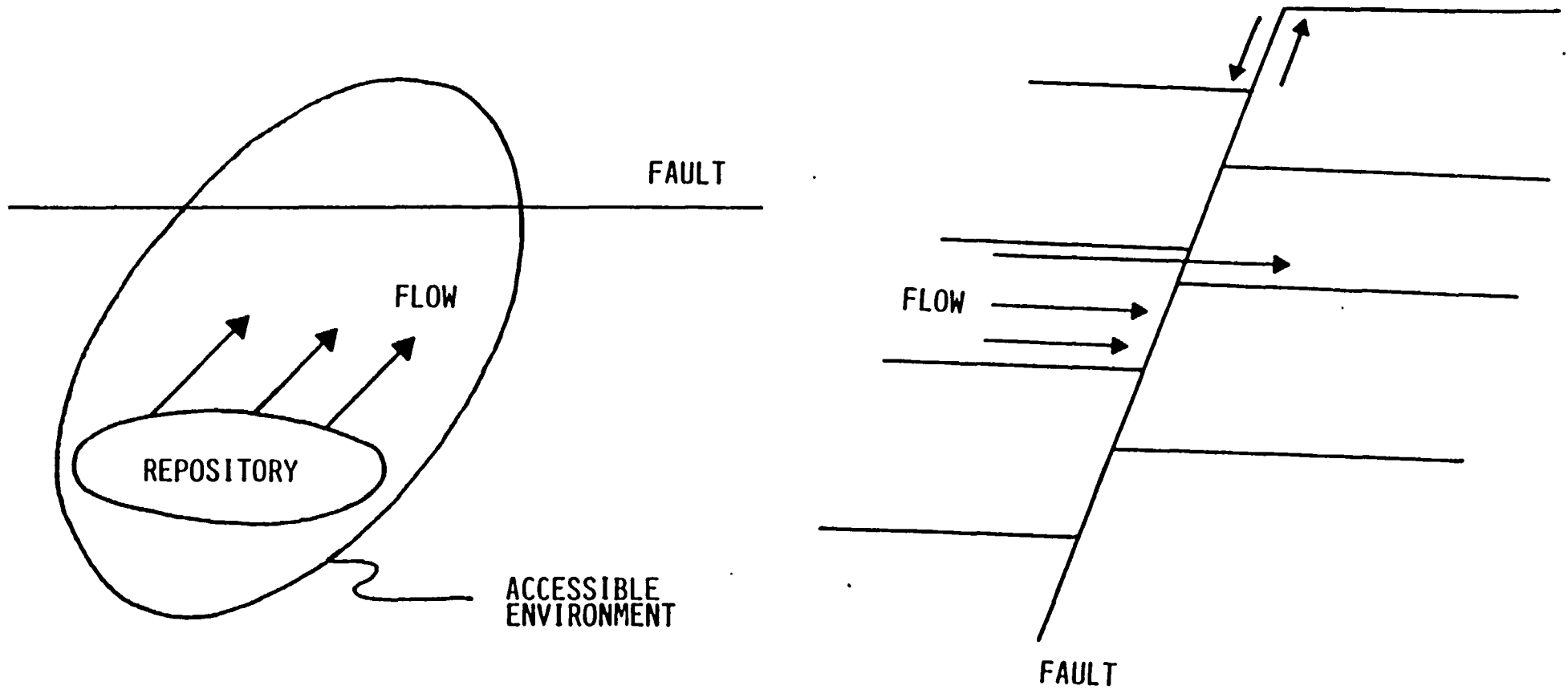
- o CANISTER CORRODES
- o GROUNDWATER LEACHES  
RADIONUCLIDES FROM  
WASTE FORM
- o GROUNDWATER CARRIES  
RADIONUCLIDES TO  
ACCESSIBLE ENVIRONMENT

### SCENARIO 2

- o CANISTER CORRODES
- o GROUNDWATER LEACHES  
RADIONUCLIDES FROM  
WASTE FORM
- o GROUNDWATER CARRIES  
RADIONUCLIDES TO  
ACCESSIBLE ENVIRONMENT
- o FAULT MOVES CHANGING  
GROUNDWATER FLOW  
SYSTEM
- o GROUNDWATER CARRIES  
RADIONUCLIDES TO  
ACCESSIBLE ENVIRONMENT  
IN MODIFIED FLOW  
SYSTEM



EARTHQUAKE SCENARIO (SCENARIO 2)



### ESTIMATE SCENARIO PROBABILITY AND CONSEQUENCES

- o DETERMINATION OF CUMULATIVE RELEASE REQUIRES
  - ESTIMATED SCENARIO PROBABILITY
  - ESTIMATED SCENARIO CONSEQUENCES
- o PROBABILISTIC ASPECT IS THE MOST CHALLENGING FEATURE OF EPA STANDARD
  - STAFF IS SPONSORING TECHNICAL ASSISTANCE
  - STAFF IS WORKING WITH DOE STATES/TRIBES AND OTHERS TO BUILD CONSENSUS ON ACCEPTABLE APPROACHES
- o EPA STANDARD
  - ALLOWS FOR SUBJECTIVE JUDGEMENTS
  - REQUIRES PROBABILISTIC ANALYSIS ONLY TO THE EXTENT PRACTICABLE
  - RECOGNIZES THE HIGH DEGREE OF UNCERTAINTY

ESTIMATE SCENARIO PROBABILITY AND CONSEQUENCES (CONT'D)

- o POSSIBLE APPROACHES
  - POINT ESTIMATES FOR BOUNDING SCENARIOS
  - DISTRIBUTIONS REPRESENTING A RANGE OF RELATED SCENARIOS
  - SOME COMBINATION OF BOTH

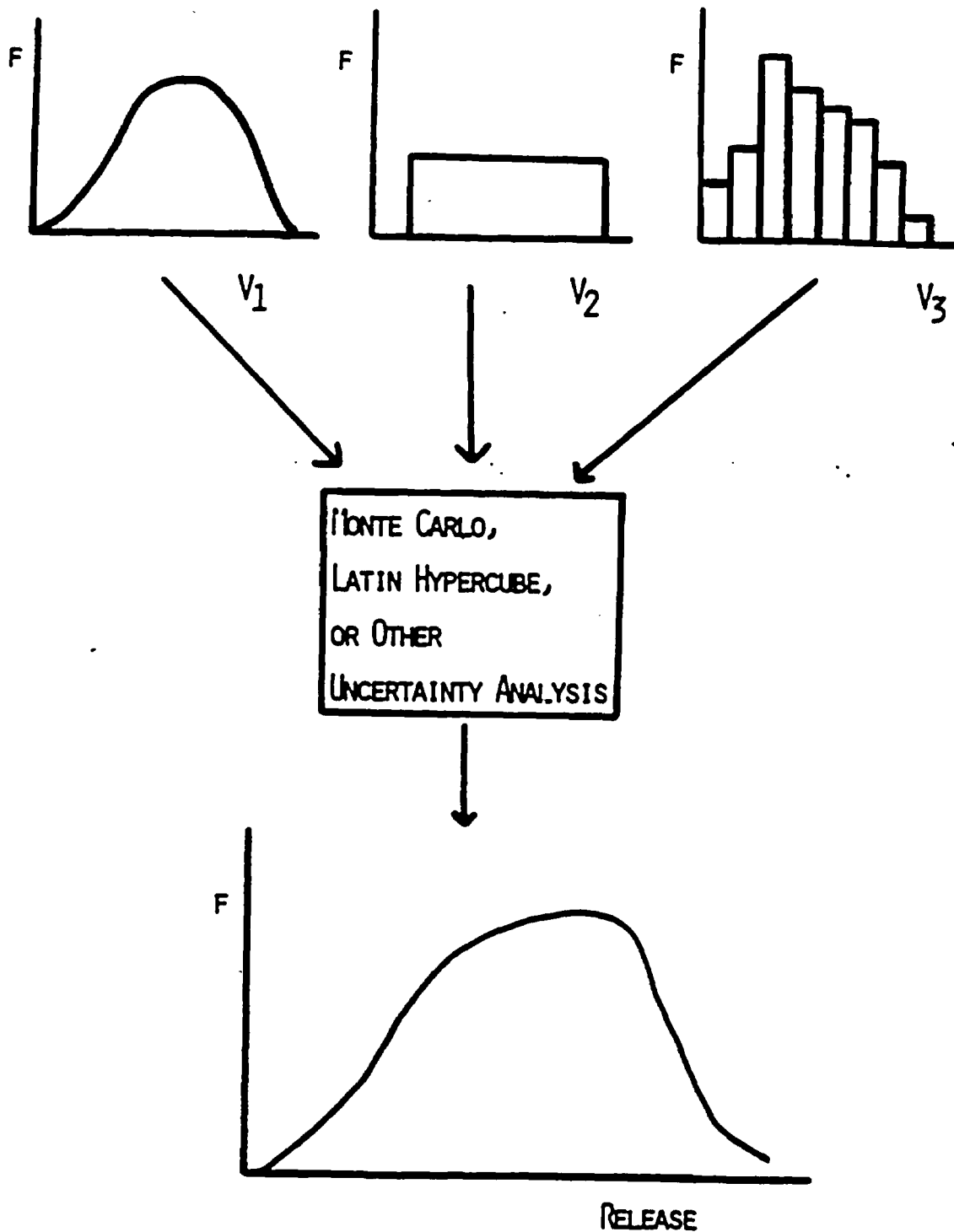
PROBABILITY OF EARTHQUAKE SCENARIO

- o ANALYSIS OF EARTHQUAKE SCENARIO REQUIRES ESTIMATE OF PROBABILITIES ASSOCIATED WITH
  - CANISTER CORROSION
  - LEACHING OF RADIONUCLIDES
  - RADIONUCLIDE TRANSPORT IN BOTH INITIAL AND MODIFIED GROUNDWATER SYSTEMS
  - FAULT MOVEMENT

### CONSEQUENCE OF EARTHQUAKE SCENARIO

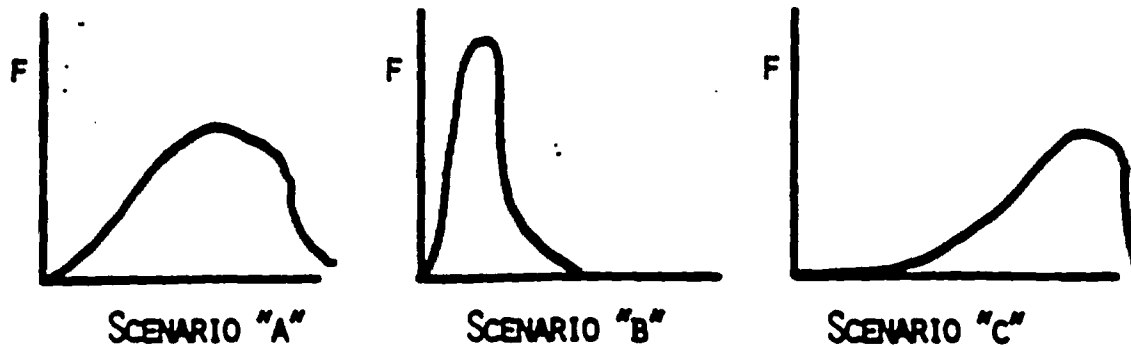
- o ANALYSIS OF EARTHQUAKE SCENARIO REQUIRES ESTIMATES OF
  - EXTENT OF CANISTER CORROSION
  - LEACH RATE
  - RATE OF TRANSPORT IN INITIAL AND MODIFIED GROUNDWATER SYSTEM
  - EXTENT OF FAULT MOVEMENT AND EFFECT ON THE GROUNDWATER SYSTEM

SCENARIO "A"—RELEASE = FUNCTION OF THREE VARIABLES,  $V_1$ ,  $V_2$ , AND  $V_3$



DISTRIBUTION OF RELEASES IF SCENARIO "A" OCCURS

# SUM SCENARIOS



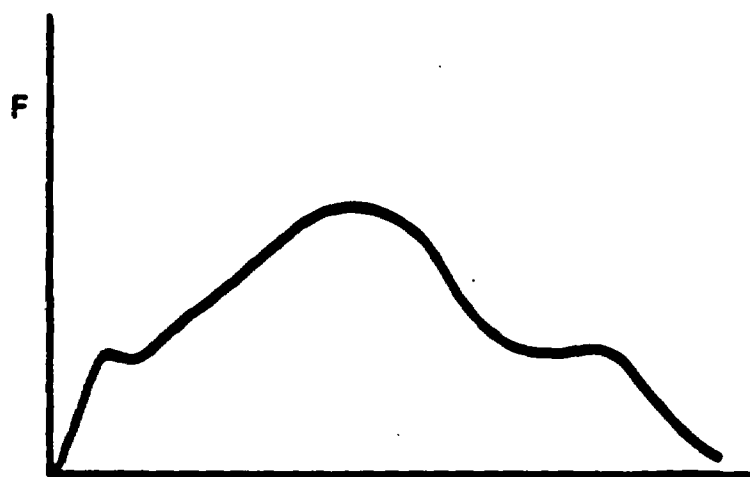
SUPPOSE SCENARIO PROBABILITIES ARE:

SCENARIO "A": 0.889

SCENARIO "B":  $10^{-1}$

SCENARIO "C":  $10^{-3}$

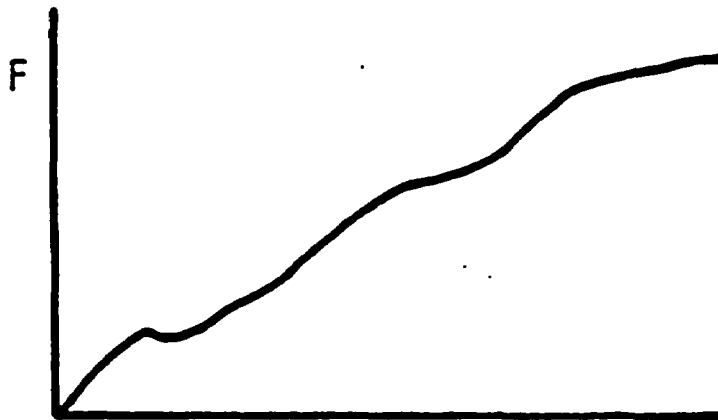
THEN MULTIPLY THE FREQUENCY SCALE FOR EACH SCENARIO BY THE PROBABILITY THAT THE SCENARIO WILL OCCUR AND SUM THE CURVES TO GET:



DISTRIBUTION OF RELEASES FROM ALL SCENARIOS

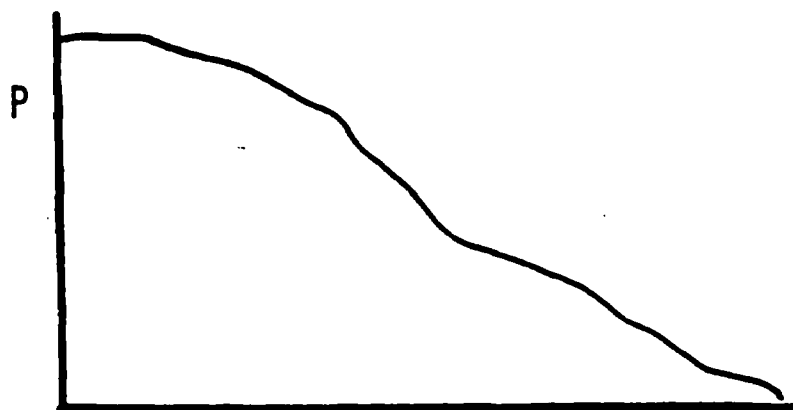
## SUM SCENARIOS

SUPPOSE WE WANT TO PLOT THE PROBABILITY THAT RELEASES WILL BE LESS THAN OR EQUAL TO A SPECIFIC VALUE. THEN INTEGRATING THE PREVIOUS CURVE GIVES:



DISTRIBUTION (OR CUMULATIVE DISTRIBUTION) FUNCTION SHOWING THE LIKELIHOOD THAT RELEASES ARE LESS THAN OR EQUAL TO A SPECIFIC VALUE.

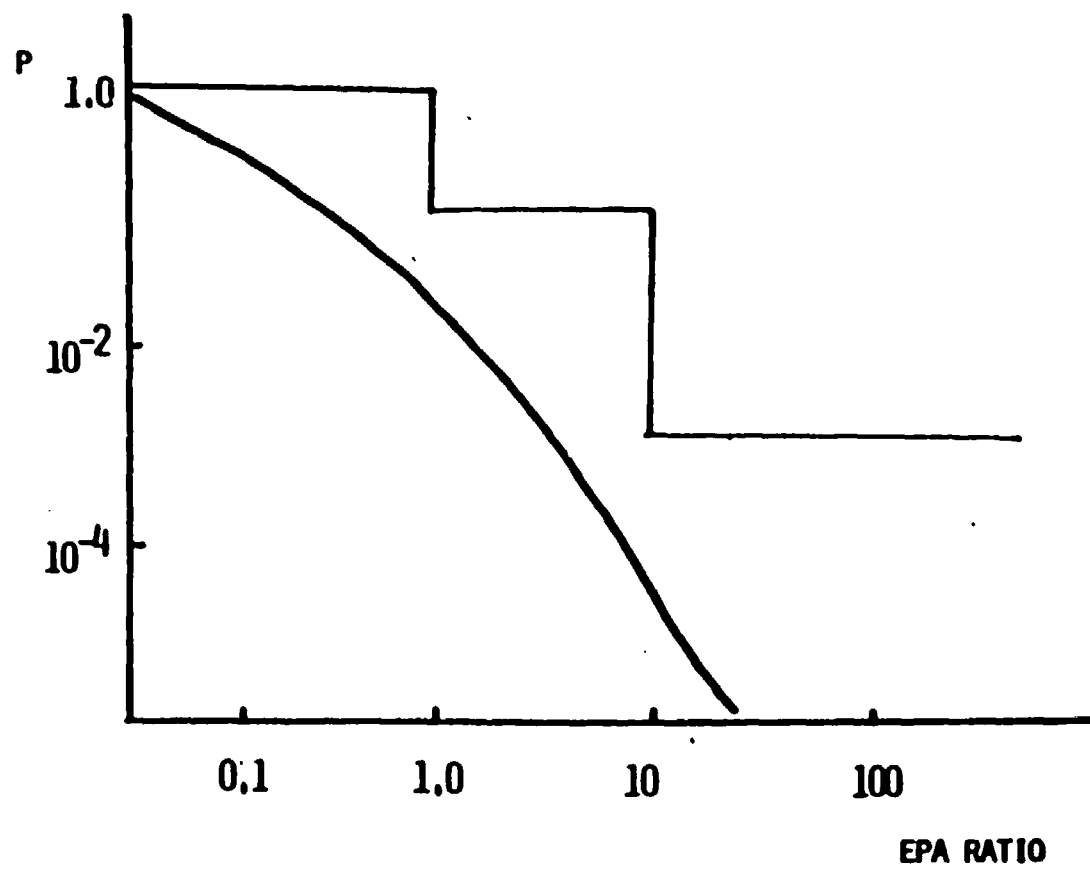
SUBTRACTING THE CURVE ABOVE FROM 1.0 GIVES THE PROBABILITY THAT RELEASES WILL BE GREATER THAN OR EQUAL TO A SPECIFIC VALUE:



COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION SHOWING THE LIKELIHOOD THAT RELEASES ARE GREATER THAN OR EQUAL TO A SPECIFIC VALUE.



COMPARE WITH STANDARD



( )

**NRC - SPONSORED PROGRAMS  
IN  
WASTE MANAGEMENT SYSTEMS**

Tito  
Bouno

**DIVISION 6416**

**FIN A1266**

- "DEVELOPMENT OF METHODOLOGIES FOR PERFORMANCE ASSESSMENT OF NUCLEAR WASTE ISOLATION IN MEDIA OTHER THAN BEDDED SALT" (RES)

**FIN A1165 - "TECHNICAL ASSISTANCE FOR PERFORMANCE ASSESSMENT" (NMSS)**

**FIN A1764 - "LLW PERFORMANCE ASSESSMENT METHODOLOGY" (NMSS)**

FIN A1266

DEVELOPMENT OF A METHODOLOGY  
FOR RISK ASSESSMENT OF  
NUCLEAR WASTE ISOLATION IN  
ALTERNATIVE GEOLOGIC MEDIA



Sandia  
National  
Laboratories

## HISTORY OF PERFORMANCE ASSESSMENT METHODOLOGY DEVELOPMENT PROGRAM

- 1976 FIN A1192 - METHODOLOGY DEVELOPMENT FOR WASTE  
- 1982 ISOLATION IN BEDDED SALT

- OBJECTIVES

- DEVELOP TOOLS AND TECHNIQUES NEEDED TO ASSESS  
LICENSE APPLICATION FOR BEDDED-SALT REPOSITORY
- DEMONSTRATE USE OF TOOLS AND TECHNIQUES

- 1982 FIN A1266 - METHODOLOGY DEVELOPMENT FOR WASTE  
- 1990 ISOLATION IN ALTERNATE MEDIA

- OBJECTIVE

- EXTEND BEDDED-SALT METHODOLOGY TO  
BASALT, TUFF, DOMED SALT AND GRANITE

*Focus is on processes & events that might  
affect disposal system*

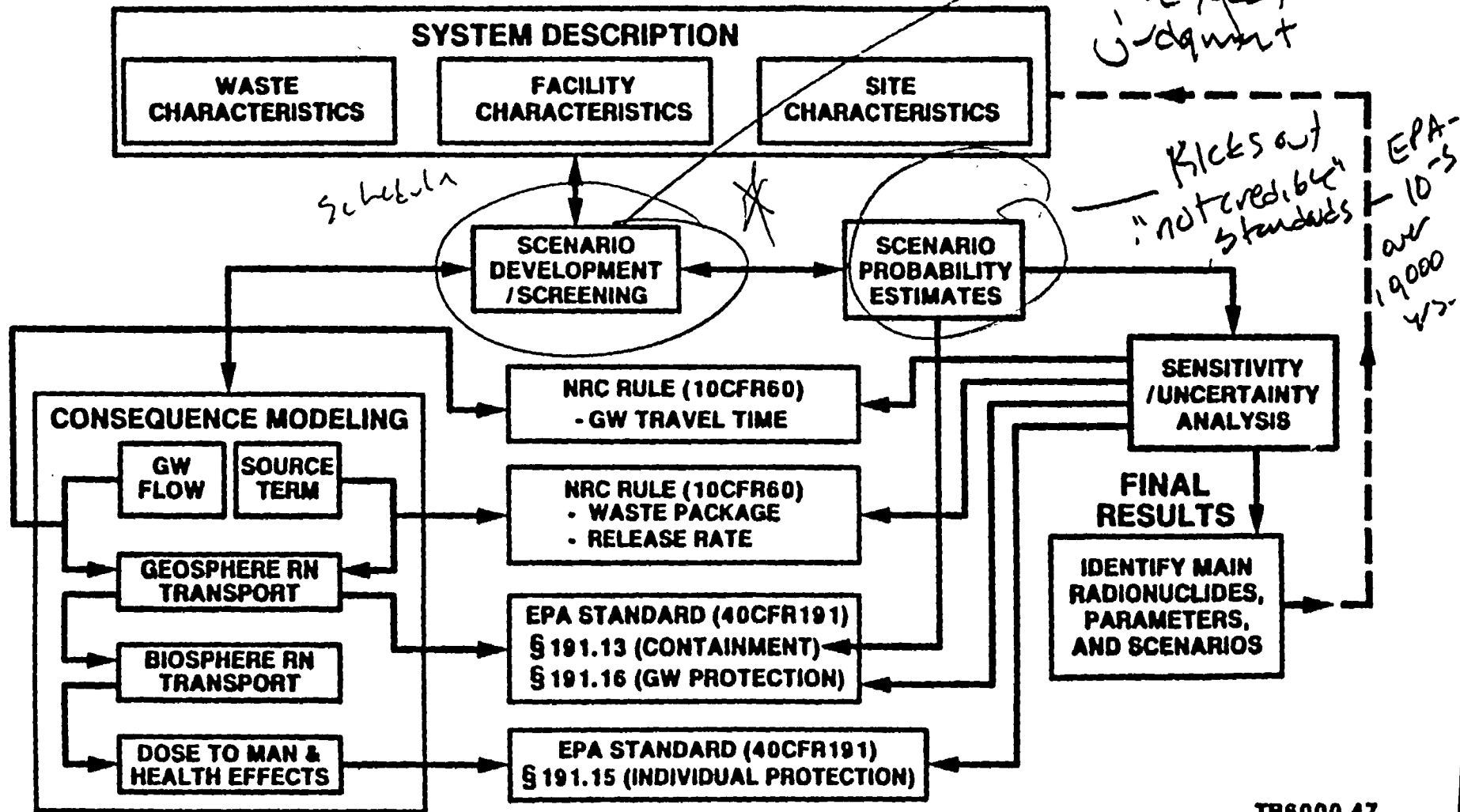
1986 - began work on  
welder & off

## **CONTENTS OF METHODOLOGY**

- **METHODS FOR SELECTING AND SCREENING SCENARIOS**
- **CODES FOR USE IN SIMULATING PHYSICAL PROCESSES AND ESTIMATING CONSEQUENCES**
- **PROBABILISTIC AND STATISTICAL TECHNIQUES FOR USE IN ESTIMATES OF RISK AND SENSITIVITY/UNCERTAINTY ANALYSES**
- **PROCEDURES FOR UTILIZING CODES AND TECHNIQUES TO EXPRESS SYSTEM RISK**

TB6000.46

# METHODOLOGY FOR PERFORMANCE ASSESSMENT OF HLW REPOSITORIES



## **ATTRIBUTES OF THE METHODOLOGY**

- **MODULAR DESIGN ALLOWS FOR EASY MODIFICATION**
- **MODULAR DESIGN ALLOWS FOR EVALUATION OF EACH REGULATION INDEPENDENTLY**
- **ABILITY TO SCREEN SCENARIOS BASED ON INTERMEDIATE RESULTS**
- **ALLOWS FOR THE IDENTIFICATION FOR KEY PARAMETERS, SCENARIOS, AND RADIONUCLIDES**

# **USE OF PERFORMANCE ASSESSMENT IN REGULATORY PROCESSES**

## **NRC RULE (10CFR60)**

- **ASSESS IMPACT (ON EPA STANDARD) OF**
  - 1) **300 - 1000 YEAR CONTAINMENT PERIOD**
  - 2)  **$10^{-5}$  PARTS/YEAR RELEASE RATE**
  - 3) **1000 YEAR GROUND-WATER TRAVEL TIME**
- **TECHNICAL SUPPORT IN DEVELOPMENT OF RATIONALE FOR**
  - 1) **DISTURBED ZONE**
  - 2) **GROUND-WATER TRAVEL TIME**

## **EPA STANDARD (40CFR191)**

- **ASSESS IMPORTANCE OF**
  - 1) **DECAY CHAINS**
  - 2) **LONGER REGULATORY PERIOD**
  - 3) **INDIVIDUAL EXPOSURES**
- **TEST IMPLEMENTATION OF STANDARD**



# **APPLICATIONS AND USES OF SNLA/ NRC PERFORMANCE ASSESSMENT METHODOLOGY**

## **OVERALL METHODOLOGY**

- **HYPOTHETICAL BEDDED-SALT AND BASALT SITES (NUREG/ CR-2452 AND NUREG/ CR-4759)**
- **WIPP SITE (IN PROGRESS)**

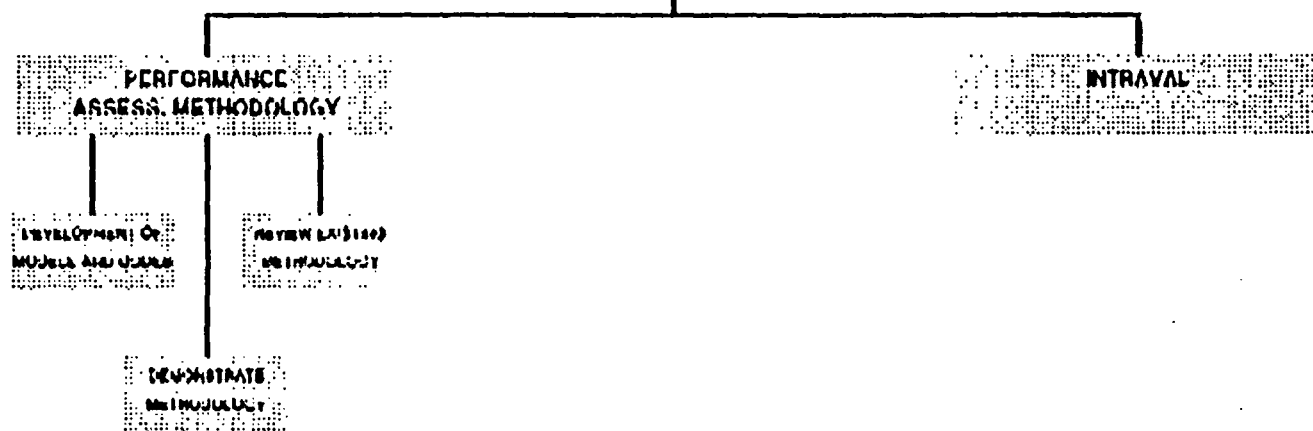
## **MODELS/ COMPUTER CODES**

- **GOVERNMENT AGENCIES AND NATIONAL LABORATORIES --- NRC, DOE, EPA, PNL, INEL**
- **UNIVERSITIES --- MIT, UA, NM TECH, U OF OKLAHOMA**
- **STATES --- MICHIGAN, ILLINOIS, MINNESOTA, VIRGINIA, NEW YORK**
- **PRIVATE INDUSTRY --- GOLDER, ADL, ROGERS ASSOC., WESTON, EBASCO, LATA, TASC, ACRES CORP., INTERA, GEOTRANS**
- **FOREIGN COUNTRIES --- GERMANY, JAPAN, KOREA, SWEDEN, UK, FINLAND**

## **SCENARIO DEVELOPMENT METHODOLOGY**

- **WIPP**
- **DOE SALT PROGRAM**
- **NEA/ OECD**
- **SKI (PROJECT 90, SWEDISH NUCLEAR POWER INSPECTORATE)**

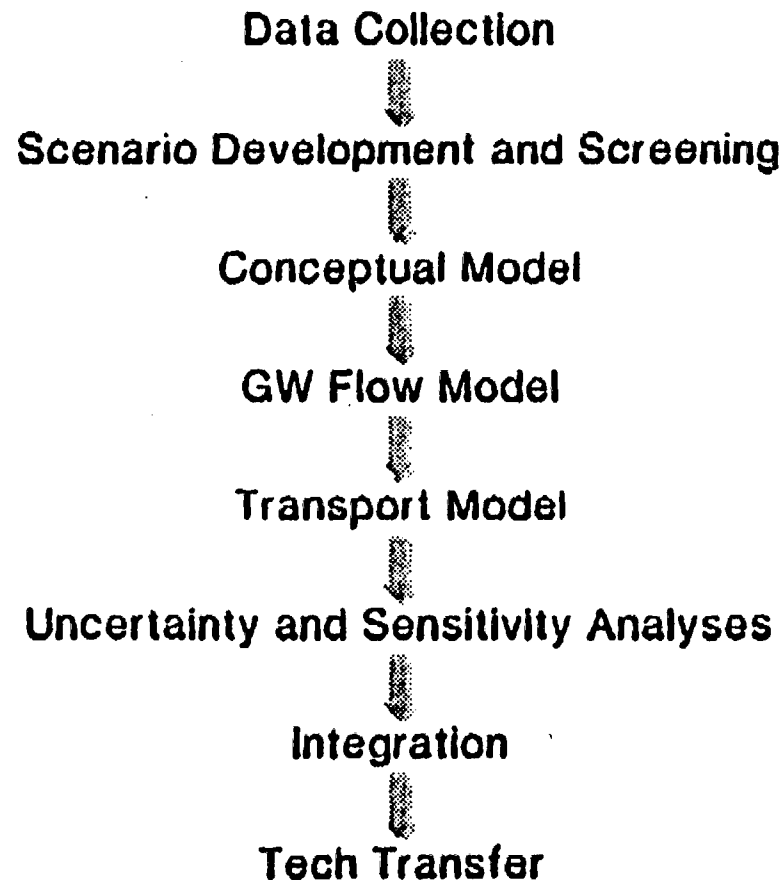
# FIN A1266



# OBJECTIVES

- Modify Components for Tuff
- Review Existing Methodology
- > Transfer Technology to CNWRA <

# APPROACH TO MODIFYING PAM FOR TUFF



# FIN A1266

## SCHEDULE AND DELIVERABLES

### FY88 - 90

#### SUBTASK

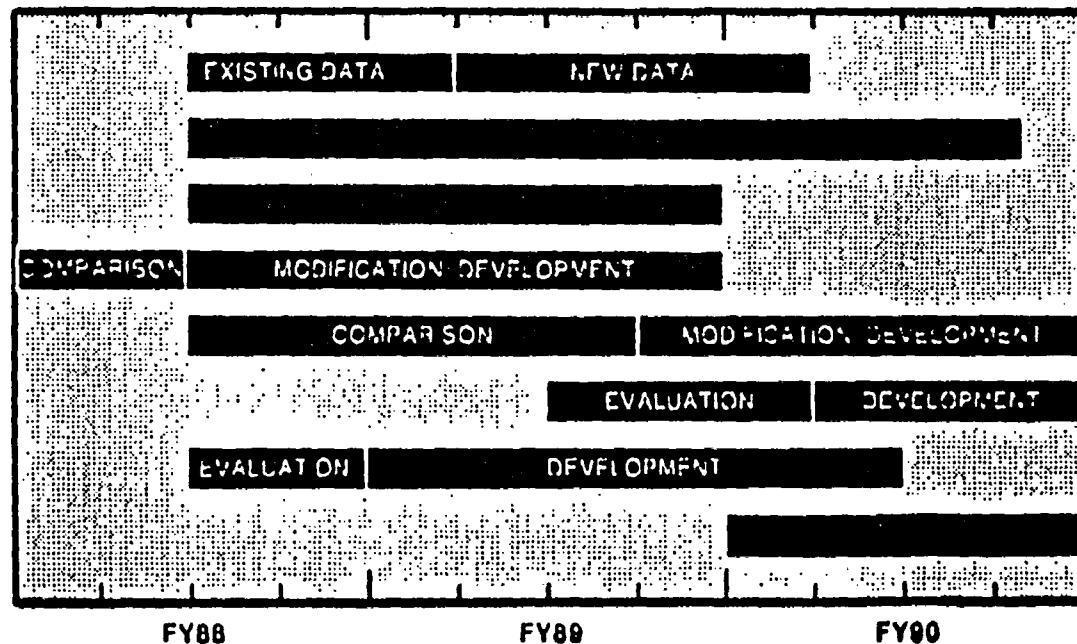
#### DELIVERABLES

DATA BASE  
DEVELOPMENT  
CONCEPTUAL MODEL  
DEVELOPMENT  
FRACTURE/MATRIX  
INTERACTIONS

GW FLOW CODE

RN TRANSPORT CODE  
UNCERTAINTY AND  
SENSITIVITY ANALYSIS  
TECHNIQUES

INVERSE  
TECHNIQUES  
INTERGRATION



**FIN A1165**

**TECHNICAL ASSISTANCE FOR PERFORMANCE ASSESSMENT**

**OBJECTIVES:**

**1) AID THE NRC STAFF IN:**

- A) REVIEWING DOE'S SITE CHARACTERIZATION PLAN**
- B) IDENTIFYING CRITICAL PARAMETERS, PROCESSES, AND CODES USED IN PERFORMANCE ASSESSMENT**
- C) RECOMMENDING APPROACHES TO REVIEWING PERFORMANCE ASSESSMENT ASPECTS OF A DOE LICENSE APPLICATION**
- D) MONITORING/REVIEWING PERFORMANCE ASSESSMENT ASPECTS OF OTHER WASTE MANAGEMENT PROGRAMS**

**2) TRANSFER TECHNOLOGY TO NRC AND CNWRA**

## **CURRENT TASKS IN THE PERFORMANCE ASSESSMENT TECHNICAL ASSISTANCE PROJECT**

- PROVIDING TECHNICAL ASSISTANCE TO THE NRC IN THE EVALUATION AND IMPLEMENTATION OF A LICENSING ASSESSMENT METHODOLOGY**
- IDENTIFICATION AND ANALYSIS OF UNCERTAINTIES ASSOCIATED WITH HLW REPOSITORY PERFORMANCE ASSESSMENTS**
- IDENTIFYING AND ANALYZING QUANTITATIVE TECHNIQUES FOR ASSIGNING PROBABILITIES OF OCCURRENCE TO POTENTIALLY DISRUPTIVE EVENTS AND PROCESSES**
- MAINTENANCE AND CONFIGURATION MANAGEMENT OF PERFORMANCE ASSESSMENT COMPUTER CODES**

## **FIN A1165**

### **WORK COMPLETED TO DATE**

- **ASSISTANCE IN REVIEW FOR PERFORMANCE ASSESSMENT ASPECTS OF DOE'S SITE CHARACTERIZATION PLAN**
- **REPORT ON COMPONENTS OF PERFORMANCE ASSESSMENT METHODOLOGY**
- **REPORT ON SCENARIO DEVELOPMENT AND SCREENING METHODOLOGY**
- **SCOPING DOCUMENT ON SOURCES OF UNCERTAINTY RELEVANT TO HLW REPOSITORY PERFORMANCE ASSESSMENT**
- **REPORT ON REVIEW OF QUANTITATIVE TECHNIQUES FOR ESTIMATING PROBABILITIES OF EVENTS AND PROCESSES THAT CAN DISRUPT HLW REPOSITORY PERFORMANCE**



**A1764**

**Low-Level Waste (LLW)**

**Performance Assessment Methodology (PAM)**

**OBJECTIVE : To develop, implement, and transfer to the NRC a PAM that provides the analytical framework necessary to demonstrate compliance with the performance objectives in 10 CFR 61.41 and 61.42.**

A1764

Low-Level Waste (LLW)  
Performance Assessment Methodology (PAM)

TASKS : *Deadlines*

- 1 Develop Detailed Work Plan, March 12, 1988
- 2 Develop LLW PAM, June 12, 1988 thru June 12, 1989
- 3 Evaluate Existing Performance Assessment Codes, April 12, 1989
- 4 Select and Implement Codes, May 12, 1989 thru August 12, 1989
- 5 Develop Self-Teaching Curriculum, February 12, 1990
- 6 Short-Term Technical Assistance, as needed

**A1764**

**Completed Tasks**

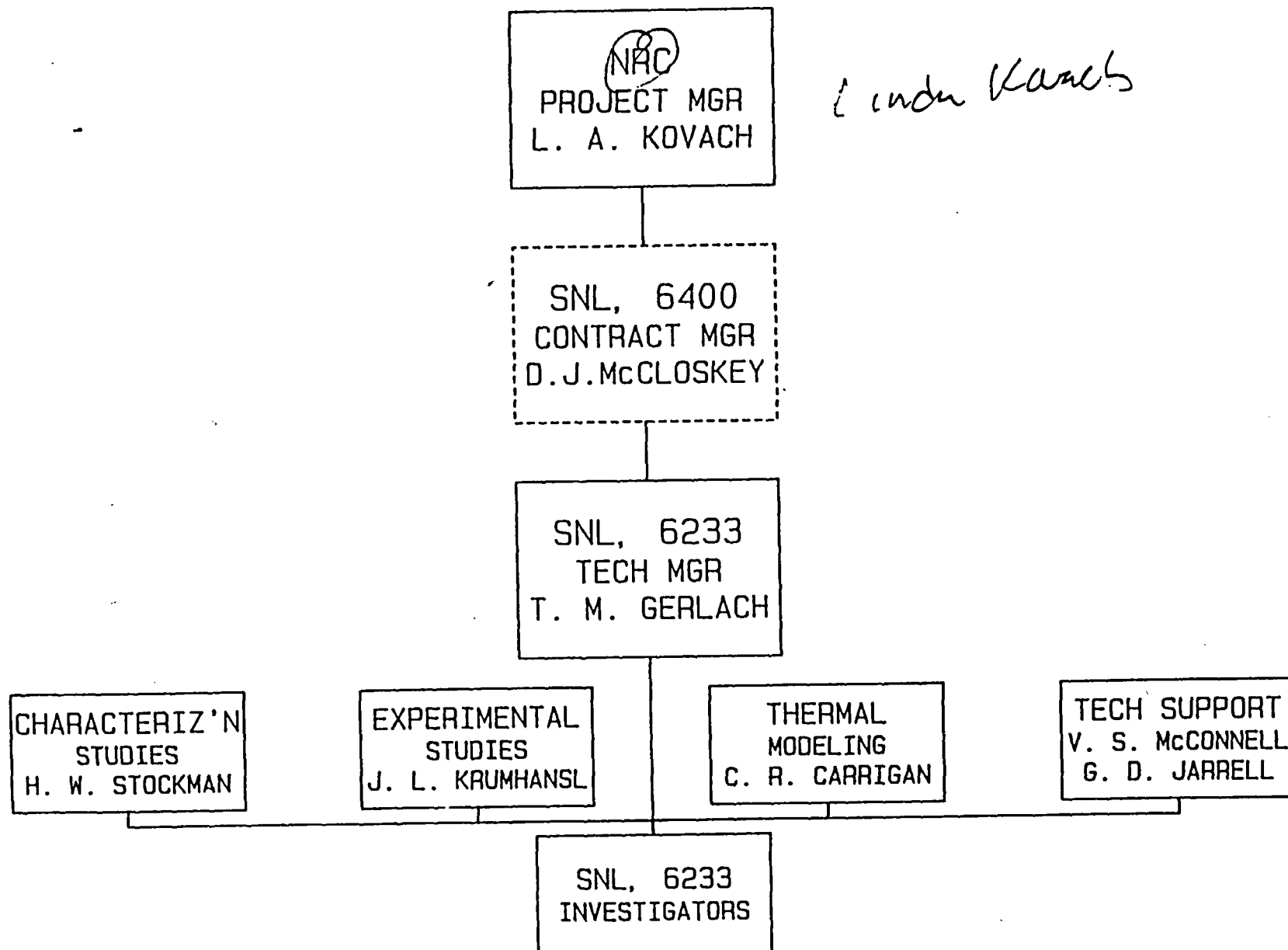
**Task 1.0 Detailed Work Plan  
March 1988**

**Task 2.1 Pathway Identification  
June 1988**

**Task 2.2 Important Pathways  
October 1988**

VALLES CALDERA NATURAL ANALOG

TERRENCE M. GERLACH  
GEOCHEMISTRY RESEARCH DIVISION 6233  
SANDIA NATIONAL LABORATORIES



## NATURAL ANALOGUES OF HLW DISPOSAL SITES

DEFINITION: A NATURAL OCCURRENCE OF MATERIALS AND/OR PROCESSES THAT ARE ANALOGOUS TO EXPECTED MATERIALS AND/OR PROCESS IN A PROPOSED GEOLOGIC WASTE REPOSITORY. (ADOPTED BY THE NATURAL ANALOGUE WORKING GROUP OF THE COMMISSION OF EUROPEAN COMMUNITIES)

## WHY STUDY NATURAL ANALOGUES?

- o A GEOLOGIC REPOSITORY OF HLW IS A NATURAL, COMPLEX SYSTEM WITH A VERY LONG OPERATING LIFE.
- o NRC HAS TO HAVE REASONABLE ASSURANCE THAT PREDICTIONS OF HLW REPOSITORY PERFORMANCE OVER AT LEAST 10,000 YEARS ARE SUFFICIENTLY ACCURATE TO PROVIDE CONFIDENCE IN LICENSING DECISIONS ABOUT HLW DISPOSAL.
  - o LABORATORY EXPERIMENTS OFFER SHORT-TERM TESTS OF SELECTED, ISOLATED PROCESSES.
  - o FIELD EXPERIMENTS OFFER SHORT-TERM TESTS OF COMPLEX PROCESSES.
  - o NATURAL ANALOGUES OFFER LONG-TERM TESTS OF COMPLEX PROCESSES AND ARE THE ONLY AVAILABLE LONG-TERM EXPERIMENTS FOR TESTING MODELS OF HLW REPOSITORY PERFORMANCE.
- o ADVANTAGES OF NATURAL ANALOGUES ARE:
  - o LONG TIME SCALES
  - o LENGTH SCALES COMPARABLE TO REPOSITORY LENGTH SCALES
  - o RECORDS OF COMPLEX, COUPLED PROCESSES
  - o LONG-TERM AND LARGE-SCALE DATA FOR VALIDATION OF MODELS THAT HAVE BE APPLIED TO LONG TERMS AND LARGE SCALES
  - o CHECKS ON SITE CHARACTERIZATION

BASIS FOR PUBLIC CONFIDENCE IN MATHEMATICAL MODELS APPLIED

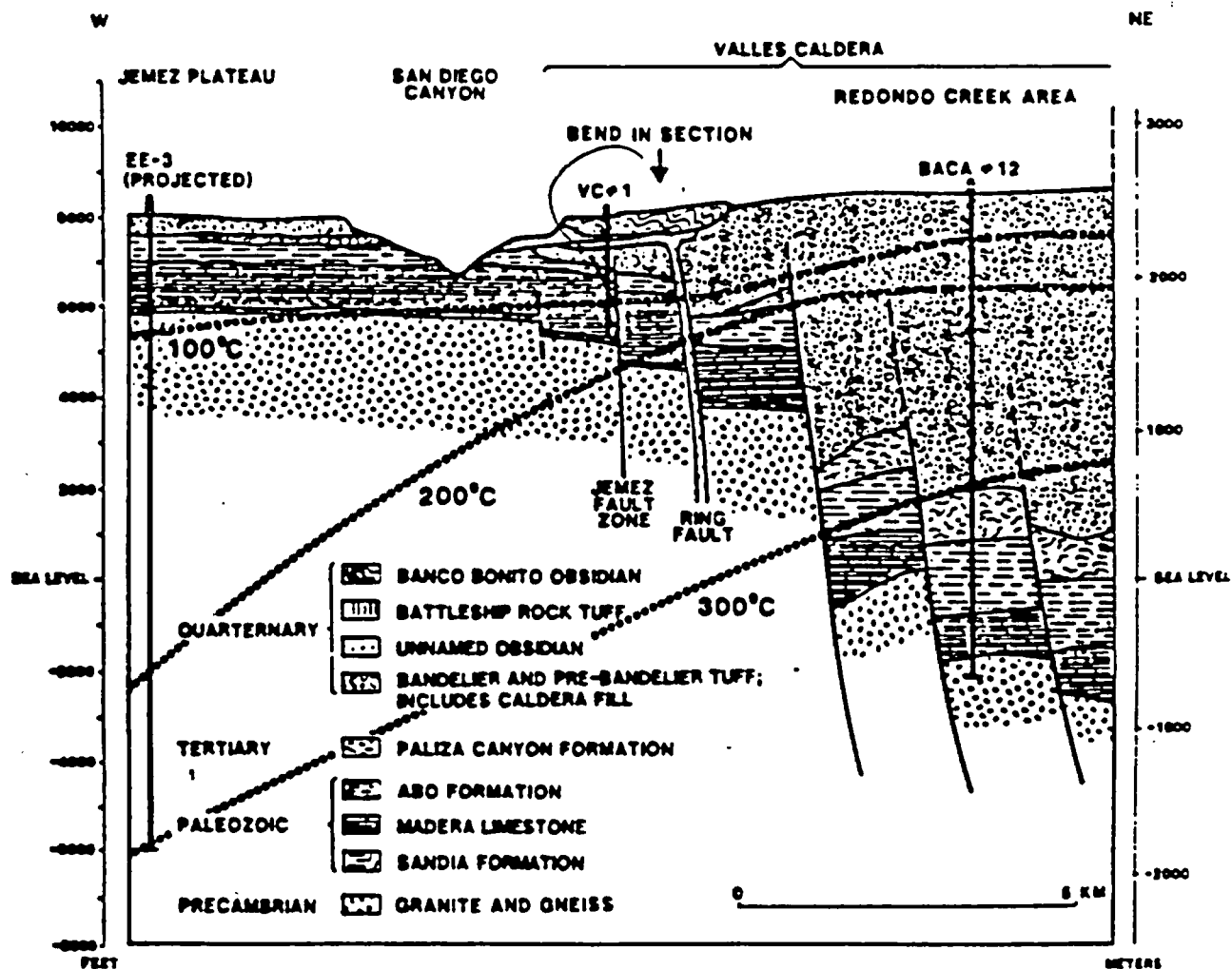
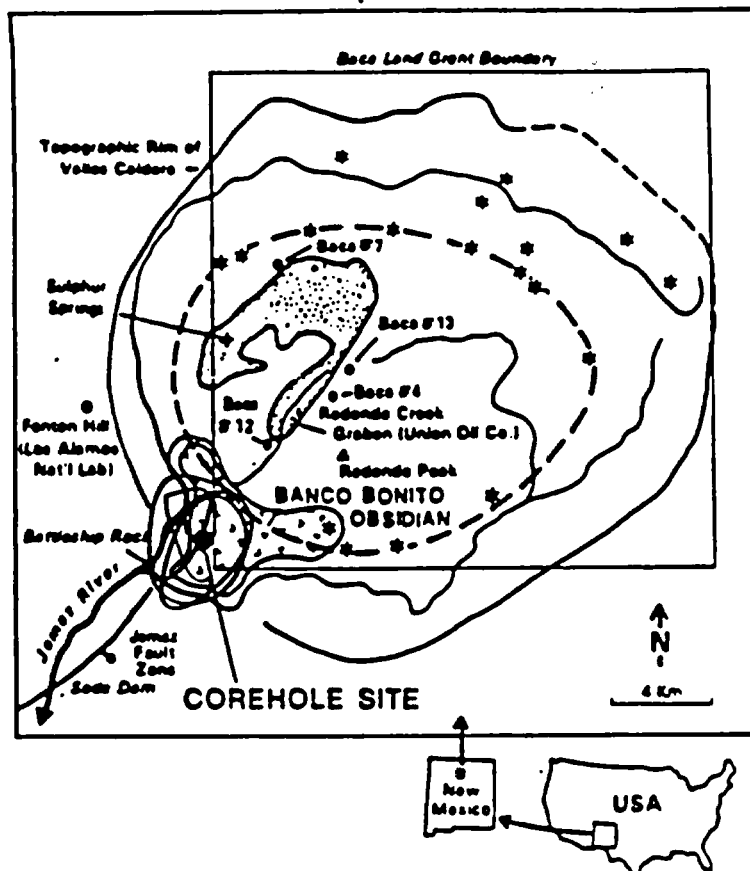
## Criteria for a Good Natural Analog

- A) Relevant host rock *hydrologic regime*
- B) Heat source approximates repository
- C) No unrelated hydrothermal overprint
- D) "Young", well-constrained age
- E) Thermal regime simple; e.g. little or no convective heat loss
- F) Unaltered "control" on pre-heating composition of host
- G) Uniform pre-heating composition/properties for host
- H) Geothermometry possible
- I) Accessible

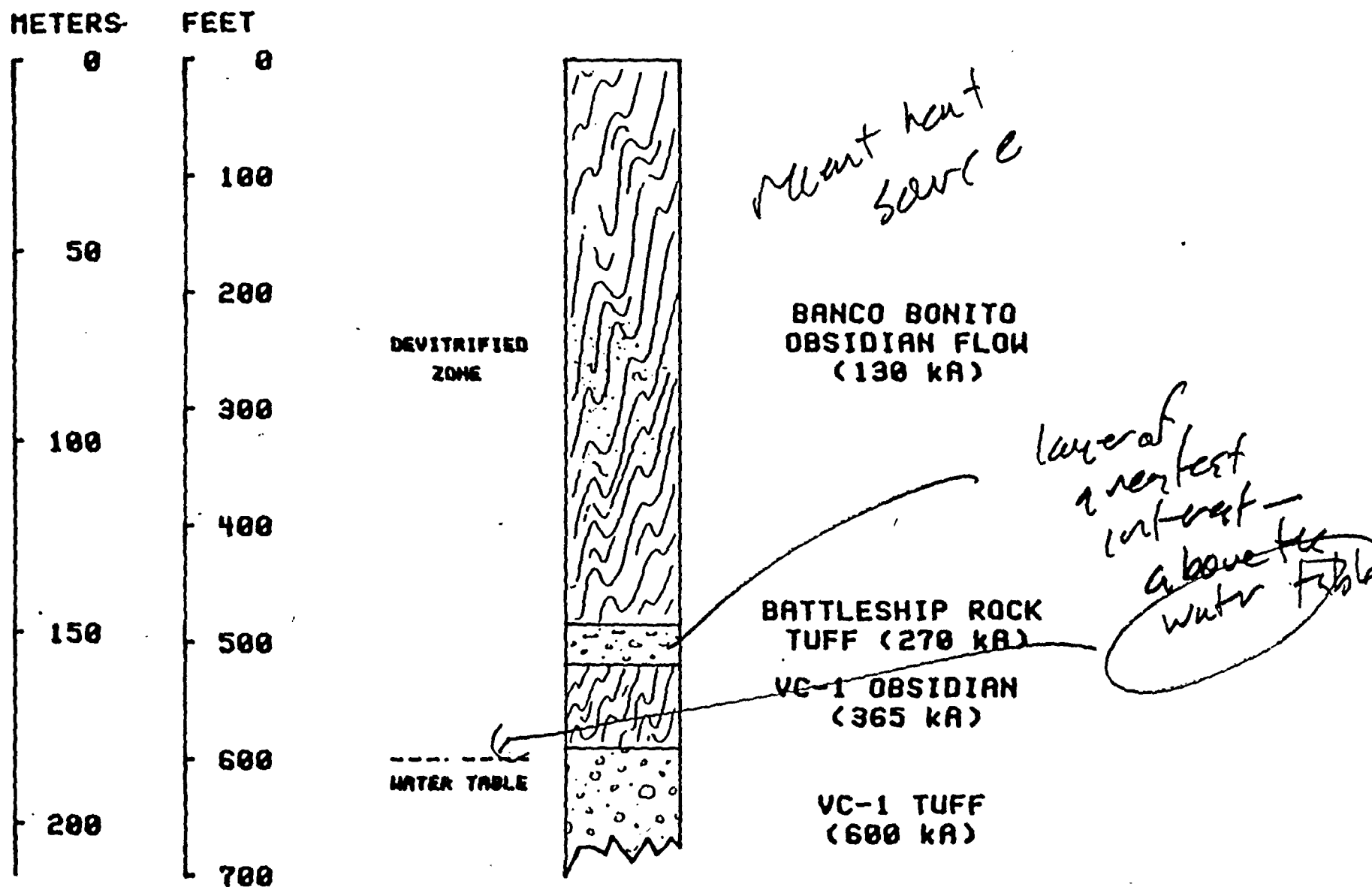


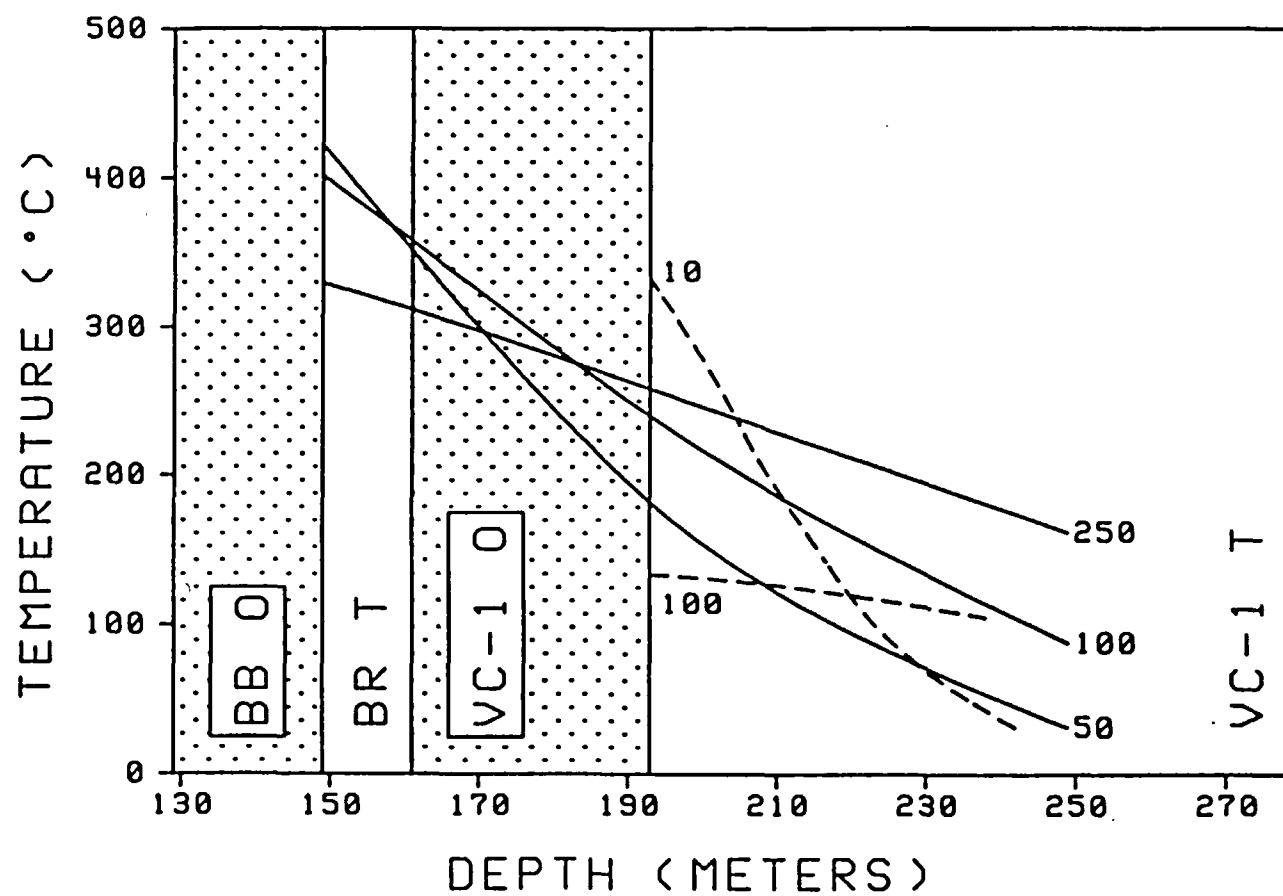
### WHY VALLES CALDERA NATURAL ANALOGUE?

THE VALLES CALDERA NATURAL ANALOGUE IS THE ONLY ONE AVAILABLE TO NRC THAT IS IN UNSATURATED TUFFS THAT ARE IN MANY WAYS SIMILAR TO THE YUCCA MOUNTAIN TUFFS.



# VC-1 STRATIGRAPHY





## ADVANTAGES OF VALLES NATURAL ANALOG

- ✓ ■ UNSATURATED, LIKE YUCCA MOUNTAIN REPOSITORY.
- SIMILAR CHEMISTRY AND LITHOLOGY TO THE TONAPAH SPRINGS TUFF OF THE REPOSITORY HORIZON AT YUCCA MOUNTAIN.
- THERMAL PULSE OF ADEQUATE DURATION, EXTENT.
- LITTLE EXTRANEEOUS ALTERATION OR OVERPRINTING. NOT IN AN ACTIVE HYDROTHERMAL ZONE.
- SIMPLER GEOLOGY THAN MOST IGNEOUS ANALOGS.
- ✗/ ■ ~~INTRUSION~~ NOT DISCORDANT.  
HORIZONTAL HEAT SOURCE.
- GOOD ACCESS VIA DRILL CORE AND OUTCROPS.

## **OBJECTIVES OF THE VALLES CALDERA NATURAL ANALOG STUDY**

- 1) Document evidence of transport in unsaturated tuffs**
- 2) Assess extent of mineralogic changes**
- 3) Compare results of short term laboratory hydrothermal experiments with the outcome of the long term natural analog study**

# **PROGRAM DESCRIPTION**

## **FIELD WORK**

- \* Examine tuffaceous units below the Banco Bonito Obsidian Flow

## **LABORATORY ACTIVITIES**

- \* Assemble a comprehensive database on heated tuff samples from both VC-1 core and outcrop samples
  - mineralogy
  - major elements
  - trace elements
- \* Hydrothermal Experiments
  - mineralogy and composition of treated tuff
  - aqueous phase chemistry
- \* Age and Temperature Determination on Samples
  - $^{39}\text{Ar} / ^{40}\text{Ar}$

## **MODELING ACTIVITIES**

- \* Thermal Profile Computation

# **ANALYTIC TOOLS**

**INAA**

**Ion chromatography**

**D.C. Plasma Spectroscopy**

**X-ray Fluorescence**

**CHEMICAL**

**COMPOSITION**

**S.E.M.**

**X-ray Diffraction**

**Petrographic Examination**

**MINERALOGY**

**AND**

**TEXTURE**



TASKS AND THEIR STATUS IN  
THE NATURAL ANALOGUE PROJECT

- 1350* O WHOLE ROCK ANALYSES OF MAJOR TRACE ELEMENTS ANALOGOUS TO FISSION PRODUCTS (NA, K, CA, AL, SI, FE, H<sub>2</sub>O, CL IONS, CS, U, TH, TA, SB, SR, ETC.) (60% COMPLETE; NUREG/CR (6/89))
- O CHARACTERIZATION OF ALTERATION PHASES TO ESTABLISH MINERALOGICAL CHANGES (40% COMPLETE; NUREG/CR (1/90))
- O THERMAL MODELING (CONDUCTION VS CONVECTION) (40% COMPLETE; NUREG/CR (1/91))
- O PALEOGEOTHERMS, AGES OF DEPOSITION (ISOTOPIC ARGON AGES TO INDICATE ROCK SOLIDIFICATION TEMPERATURES) (60% COMPLETE; NUREG/CR (6/89))
- O EXPERIMENTAL STUDIES (EVALUATION OF SHORT-TERM LABORATORY EXPERIMENTS TO PREDICT LONG-TERM PROCESSES; MOBILIZATION OF TRACE ELEMENTS IN CLOSED, OPEN, AND REFLUX SYSTEMS) (35% COMPLETE; NUREG/CR (9/90))
- O SYNTHESIS OF RESULTS AND GEOCHEMICAL MODELING (COMBINING RESULTS OF CHEMICAL ANALYSES, OTHER LABORATORY EXPERIMENTS, AND THERMAL MODELING TO OBTAIN A CONSISTENT PICTURE OF THE EVOLUTION OF THE NATURAL ANALOGUE) (30% COMPLETE; NUREG/CR (1/91))

# The Search For Evidence Of Transport

## Rock Analyses

- \* whole rock
- \* clasts
- \* matrix

Concentration profiles documented for five feet below the contact at "outcrop 8" and in the VC-1 core

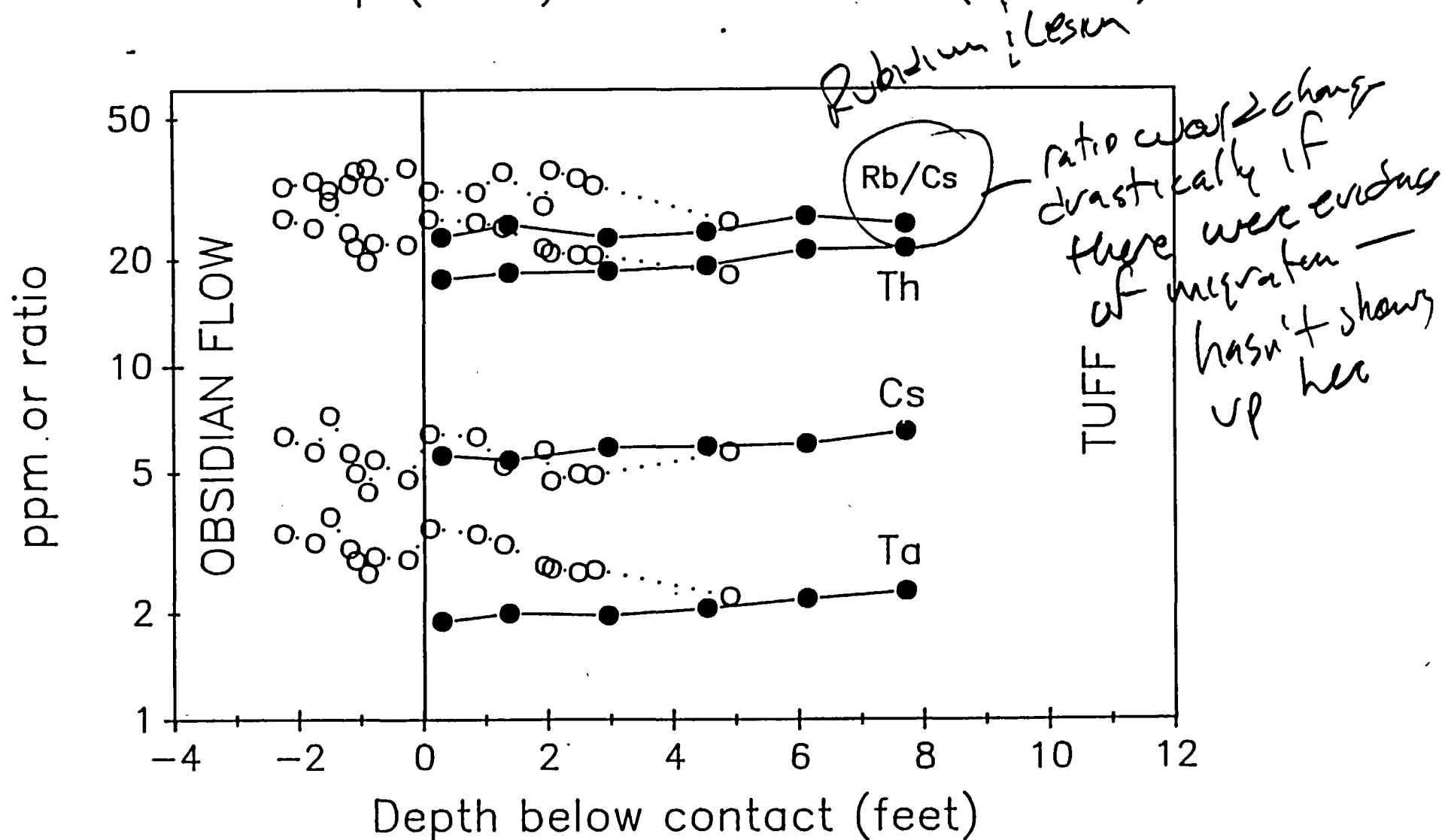
Both suites of rocks examined for Cl, Sc, Cs, Eu, Tb, Yb, Hf, Ta, Th, Rb, Ba, Nd, Lu, and others

**Finding:** The thermal event failed to mobilize most components.

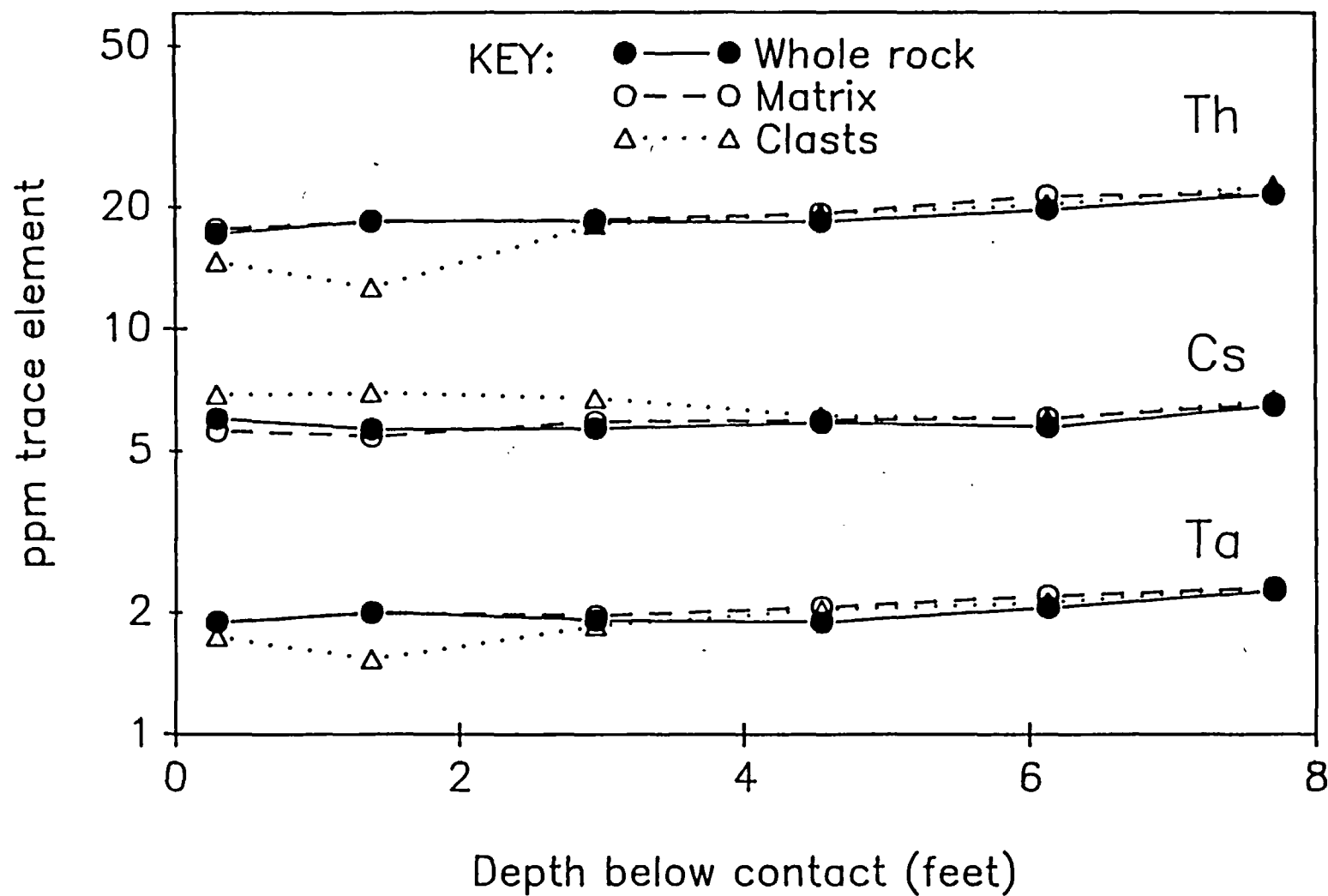
- \* Cl and H<sub>2</sub>O are exceptions; H<sub>2</sub>O pattern may be obscured by re-adsorption.

Strong evidence  
that there isn't  
much migration  
of elements  
the tube

Outcrop (solid) vs. VC-1 core (dotted)



# Outcrop: matrix, whole rock, and clasts



## **The Search For Mineralogic Alteration Effects**

**Only very small amounts of clay (montmorillonite?) were found.**

**Other secondary minerals found are highly soluble and result from drying of present-day "ground" waters.**

**Outcrop samples were fresher than VC-1 core.**

**Finding: In general the tuffs are still very fresh.**

*very little mineralogic  
change*

## Preliminary Hydrothermal Experimental Results

- \* Fresh Panum Crater obsidian with deionized water at 150° and 250°C.
- \* Alteration products similar to VC-1 clays were seen.
- \* Fluid chemistry was obtained:

	1 month 250°C	1 month 150°C	11 months 150°C
pH	8.2	8.6	~9
Sc (ppm)	342	163	263
Fe (ppm)	0.23	0.35	0.52
Ca (ppm)	< 0.1	< 0.1	0.5
Mg (ppm)	0.211	0.5	26
Al (ppm)	12.7	17.6	8.4
K (ppm)	7	5	7
Na (ppm)	74	53	78

Finding: Elemental transport requires solubility in basic solutions.

✓ Finding: Clays developed in less than a year.

✓

## PRELIMINARY CONCLUSION

HEATING A LARGE MASS OF UNSATURATED TUFF  
CAUSES LITTLE OR NO ELEMENT TRANSPORT  
AND ONLY MINOR MINERAL ALTERATION.

BRIEFING FOR COMMISSIONER CURTISS  
ON HIGH LEVEL WASTE PROGRAMS AT SANDIA LABORATORY

DECEMBER 7, 1988

4.000 - 17-00



## HIGH LEVEL WASTE RESEARCH

### OBJECTIVE

- o PROVIDE TECHNICAL BASIS FOR INDEPENDENT ASSESSMENT USED TO LICENSE DOE HLW REPOSITORY

### BASIS FOR PROGRAM

- o LEGISLATIVE MANDATE: NWPA (1982), NWPAA (1987)
- o NEW TECHNOLOGY - NO OPERATIONAL EXPERIENCE

### FOCUS

- o PERFORMANCE ASSESSMENT FOR YUCCA MOUNTAIN HYDROGEOLOGY (UNSATURATED, FRACTURED TUFF SETTING)
- o CONFIRMING MATERIALS AND ENGINEERED SYSTEMS PERFORMANCE
- o PROPOSED REVISIONS TO HLW REGS (10 CFR 60)

## HIGH-LEVEL WASTE PROGRAM ACTIVITIES

### o MATERIALS AND ENGINEERING

- WASTE PACKAGE CORROSION
- SEALING OF BOREHOLES/SHAFTS
- SEISMIC EFFECTS/ROCK MECHANICS

### o HYDROLOGY AND GEOCHEMISTRY

- GROUND-WATER FLOW AND TRANSPORT THRU UNSATURATED FRACTURED MEDIA
- NEAR-FIELD GEOCHEMISTRY
- RADIONUCLIDE SORPTION/TRANSPORT

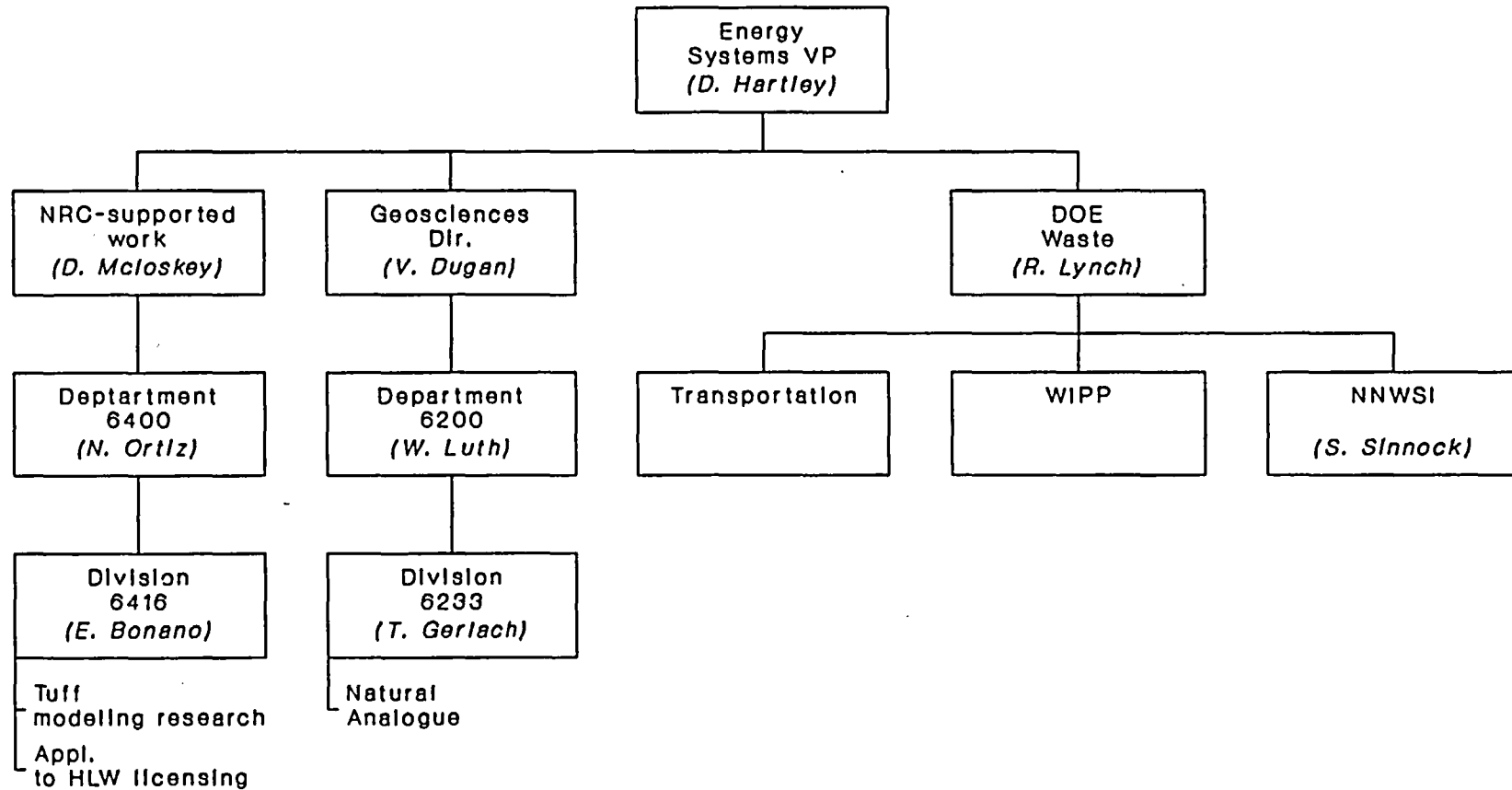
### o COMPLIANCE ASSESSMENT AND MODELING

- INDEPENDENT PERFORMANCE ASSESSMENT METHODOLOGY
- VALIDATION: FIELD AND NATURAL ANALOG STUDIES

### o SUPPORT OF RULEMAKING

NRC-SUPPORTED  
HIGH-LEVEL RADIOACTIVE WASTE  
PROJECTS AT  
SANDIA NATIONAL LABORATORIES

# Sandia Waste Management Work Organizational Structure



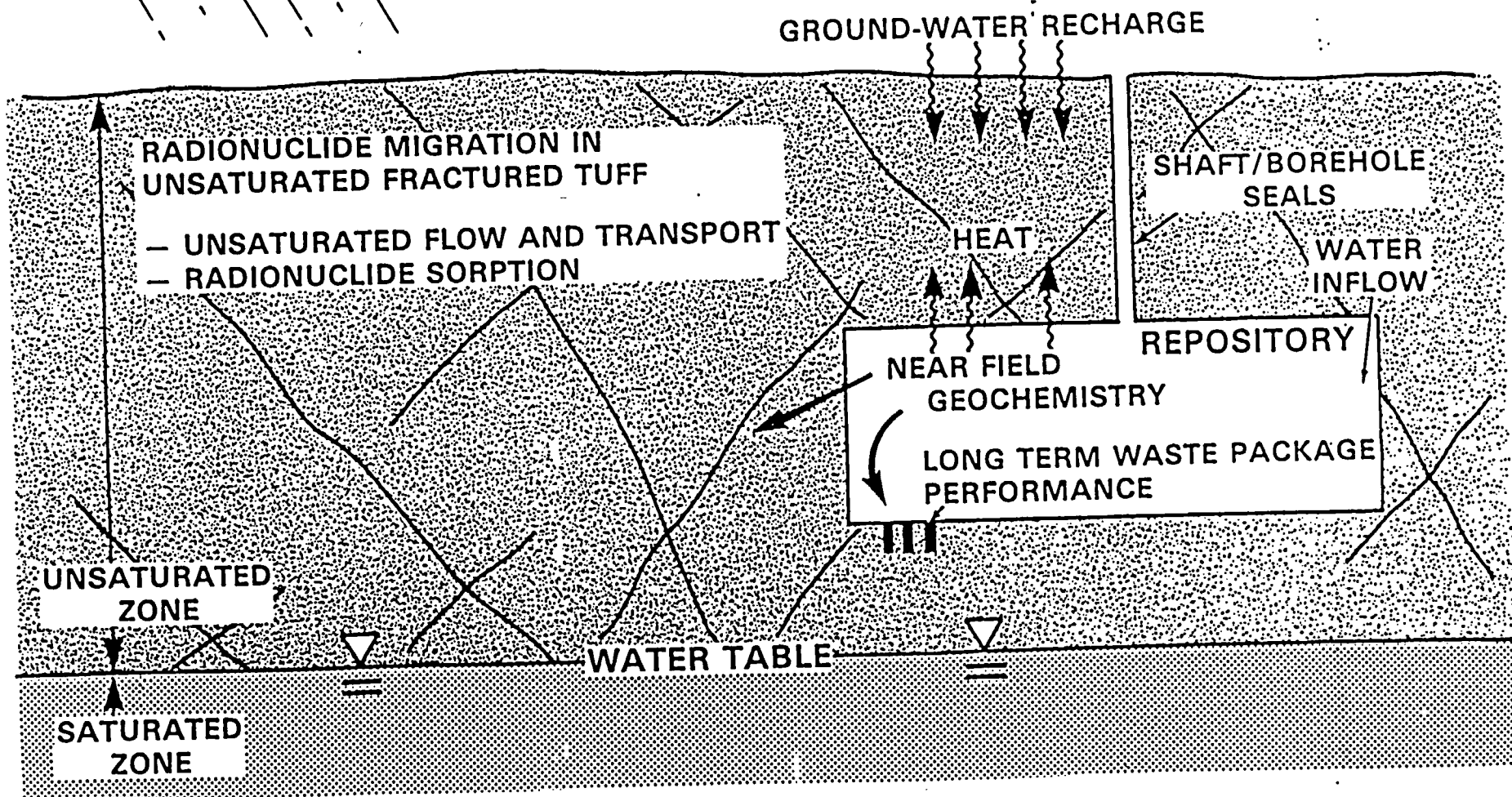
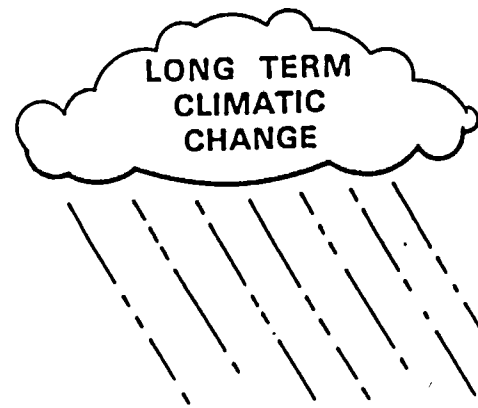
CURRENT NRC-SPONSORED HLW PROJECTS  
AT SNL

- O "DEVELOPMENT OF A METHODOLOGY FOR PERFORMANCE ASSESSMENT OF NUCLEAR WASTE ISOLATION IN ALTERNATIVE GEOLOGIC MEDIA"  
(ALTERNATIVE TO BEDDED SALT, CURRENT EMPHASIS IS ON UNSATURATED WELDED TUFF) (RES)
- O "TECHNICAL ASSISTANCE FOR PERFORMANCE ASSESSMENT" (NMSS)
- O "A NATURAL ANALOGUE FOR A HIGH-LEVEL WASTE REPOSITORY:  
CHEMICAL MIGRATION AND THERMAL EFFECTS IN THE VC-1 COREHOLE,  
VALLES CALDERA, NEW MEXICO" (RES)

## HLW PERFORMANCE ASSESSMENT

THE PROCESS OF QUANTITATIVELY EVALUATING COMPONENT AND SYSTEM BEHAVIOR, RELATIVE TO CONTAINMENT AND ISOLATION OF RADIOACTIVE WASTE, TO SUPPORT DEVELOPMENT OF A REPOSITORY OF HLW AND TO DETERMINE COMPLIANCE WITH THE NUMERICAL CRITERIA ASSOCIATED WITH THE REGULATION 10 CFR 60.

# HIGH-LEVEL WASTE



## *Relationship of Performance Assessment Research to Other NRC HLW Research and Technical Assistance*

### SHORT-TERM TESTS

Site  
Characterization  
(U of Arizona)

Engineered  
Barriers  
(NIST, etc.)

### NRC PERFORMANCE ASSESSMENT

Performance  
Assessment  
Research  
(*Sandia*)

Application  
of Models to  
HLW Licensing  
(*Sandia*)

### LONG-TERM APPROACHES

Natural Analogues,  
(*Sandia, Australia*)

Laboratory  
Simulations  
(CNWRA, Colorado  
State)

International  
Efforts  
(INTRAVAL,  
HYDROCOIN,  
INTRAVAL,  
NEA)



NRC-SUPPORTED HLW PERFORMANCE ASSESSMENT  
RESEARCH AT SANDIA

"DEVELOPMENT OF A METHODOLOGY FOR  
PERFORMANCE ASSESSMENT OF NUCLEAR WASTE  
ISOLATION IN ALTERNATIVE GEOLOGIC MEDIA"

OBJECTIVE: TO MODIFY THE PERFORMANCE ASSESSMENT METHODOLOGIES  
DEVELOPED FOR ISOLATION OF HIGH-LEVEL RADIOACTIVE WASTE IN  
BEDDED SALT AND BASALT SO AS TO OBTAIN A PERFORMANCE  
ASSESSMENT METHODOLOGY THAT IS APPLICABLE TO ISOLATION OF  
HLW IN UNSATURATED WELDED TUFF.

CURRENT TASKS IN THE  
PERFORMANCE ASSESSMENT  
RESEARCH PROJECT

- o METHODOLOGY DEVELOPMENT FOR PERFORMANCE ASSESSMENT OF  
RADIOACTIVE WASTE ISOLATION IN WELDED TUFF
- o CALCULATIONS IN SUPPORT OF INTRAVAL

STATUS OF PERFORMANCE ASSESSMENT  
RESEARCH PROJECT

TUFF METHODOLOGY TASK

- O A COMPARISON OF THE CHARACTERISTICS OF BEDDED SALT, BASALT, AND TUFF (COMPLETE; LETTER REPORT)
- O A COMPARISON OF COMPUTER PROGRAMS THAT IMPLEMENT MATHEMATICAL MODELS OF WATER MOVEMENT IN UNSATURATED MEDIA (COMPLETE; NUREG/CR, CONFERENCE PAPER)
- O DEVELOPMENT OF RELEASE SCENARIOS FOR THE TUFF METHODOLOGY (COMPLETE; NUREG/CR)
- O FINANCIAL SUPPORT OF AND PARTICIPATION IN THREE WORKSHOPS (CONDUCTED IN 1982, 1984, AND 1986 IN COOPERATION WITH THE UNIVERSITY OF ARIZONA) ON THE FLOW OF GROUNDWATER AND TRANSPORT OF RADIONUCLIDES IN UNSATURATED TUFF (COMPLETE; TRIP REPORTS CONTAINING WORKSHOP DOCUMENTS)
- O AN ANALYSIS OF VAPOR PHASE TRANSPORT IN UNSATURATED TUFF (COMPLETE; NUREG/CR)
- O INVESTIGATION OF PERTURBATIONS TO LIQUID/VAPOR EQUILIBRIA IN UNSATURATED WELDED TUFF (50% COMPLETE; NUREG/CR, JOURNAL ARTICLE, 9/89)
- O DEVELOPMENT OR MODIFICATION OF COMPUTER PROGRAM FOR SIMULATING GROUNDWATER FLOW IN UNSATURATED TUFF (50% COMPLETE)
- O ANALYSIS OF GROUNDWATER TRAVEL TIME IN UNSATURATED TUFF (50% COMPLETE; LETTER REPORTS, 3/89 AND 9/89)

- O DEVELOPMENT OF A CONCEPTUAL MODEL FOR A HYDROLOGICAL SYSTEM IN UNSATURATED WELDED TUFF (40% COMPLETE; NUREG/CR (3/89), TO BE DISCUSSED IN FINAL PROJECT REPORT)
- O PREPARATION OF COMPUTER PROGRAMS FOR IMPLEMENTING MATHEMATICAL MODELS OF RADIONUCLIDE TRANSPORT IN UNSATURATED WELDED TUFF (JUST STARTED, LETTER REPORT (3/89), NUREG/CR (9/90))
- O ASSEMBLY OF DATA NEEDED TO DEMONSTRATE THE APPLICATION OF THE FLOW AND TRANSPORT MODELS ASSEMBLED IN PREVIOUS SUBTASKS TO UNSATURATED WELDED TUFF (50% COMPLETE; NUREG/CR (12/89))
- O UNCERTAINTY AND SENSITIVITY ANALYSIS TECHNIQUES FOR THE UNSATURATED WELDED TUFF METHODOLOGY (JUST STARTED; LETTER REPORT (3/89), NUREG/CR (9/90))
- O INTEGRATION OF RESULTS OF PREVIOUS SUBTASKS LISTED HERE AND TECHNOLOGY TRANSFER TO THE NRC STAFF AND NRC'S CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES (CNWRA) (JUST STARTED; LETTER REPORT (12/88), NUREG/CR (9/90))

## INTRAVAL TASK

### O SOLUTION OF INTRAVAL PROBLEMS (33.3% COMPLETE)

- 1) THE APACHE LEAP TUFF SITE (FROM FIN D1662).
- 2) THE BOREHOLE EXPERIMENT IN G-TUNNEL AT THE NEVADA TEST SITE.
- 3) THE LAS CRUCES TRENCH STUDY (FROM FIN B5694).

### O TECHNOLOGY TRANSFER (10% COMPLETE)

NRC-SUPPORTED HLW PERFORMANCE ASSESSMENT  
TECHNICAL ASSISTANCE AT SANDIA

"TECHNICAL ASSISTANCE FOR PERFORMANCE ASSESSMENT"

OBJECTIVE: TO PROVIDE TECHNICAL ASSISTANCE TO NRC ON HLW PERFORMANCE ASSESSMENT ISSUES RELATED TO REVIEWING DOE'S SITE CHARACTERIZATION PLANS, PROVIDING PRE-LICENSING GUIDANCE TO DOE, IDENTIFYING NEEDED NRC RESEARCH FOR MODELING PROCESSES THAT MAY AFFECT HLW REPOSITORY PERFORMANCE, AND REVIEWING DOE'S APPLICATION FOR HLW DISPOSAL.

CURRENT TASKS IN THE  
PERFORMANCE ASSESSMENT  
TECHNICAL ASSISTANCE PROJECT

- O PROVIDING TECHNICAL ASSISTANCE TO THE NRC IN THE EVALUATION AND IMPLEMENTATION OF A LICENSING ASSESSMENT METHODOLOGY
- O IDENTIFICATION AND ANALYSIS OF UNCERTAINTIES ASSOCIATED WITH HLW REPOSITORY PERFORMANCE ASSESSMENTS
- O IDENTIFYING AND ANALYZING QUANTITATIVE TECHNIQUES FOR ASSIGNING PROBABILITIES OF OCCURRENCE TO POTENTIALLY DISRUPTIVE EVENTS AND PROCESSES
- O MAINTENANCE AND CONFIGURATION MANAGEMENT OF PERFORMANCE ASSESSMENT COMPUTER CODES

STATUS OF PERFORMANCE ASSESSMENT  
TECHNICAL ASSISTANCE PROJECT

LICENSING ASSESSMENT METHODOLOGY

- O IDENTIFICATION OF TECHNICAL COMPONENTS OF PERFORMANCE ASSESSMENT METHODOLOGY (COMPLETE; LETTER REPORT, NUREG/CR (EXISTS AS DRAFT))
- O ASSEMBLY OF COMPUTER PROGRAMS THAT IMPLEMENT MATHEMATICAL MODELS RELATED TO EACH TECHNICAL COMPONENT OF PERFORMANCE ASSESSMENT (60% COMPLETE; NUREG/CR (4/89))
- O RECOMMENDATION OF A TECHNICAL BASIS FOR NRC REVIEW OF DOE'S HLW MODELING PROGRAM (60% COMPLETE; LETTER REPORTS (9/88, 11/88, 1/89), NUREG/CR (5/89))



## UNCERTAINTIES TASK

- O TECHNIQUES FOR IMPLEMENTATION OF EPA'S HLW STANDARD (40 CFR 191) (90% COMPLETE; NUREG/CR (12/88))
- O IDENTIFICATION OF SOURCES OF UNCERTAINTY; TECHNIQUES FOR QUANTIFYING AND REDUCING UNCERTAINTY IN HLW PERFORMANCE ASSESSMENTS (COMPLETE; NUREG/CR (DRAFT))
- O USE OF EXPERT JUDGMENT IN DEALING WITH UNCERTAINTIES IN HLW PERFORMANCE ASSESSMENTS (80% COMPLETE; NUREG/CR (1/89))
- O DESCRIPTION OF METHODOLOGIES FOR ANALYZING MODEL UNCERTAINTY (70% COMPLETE; LETTER REPORT (12/89); NUREG/CR (2/89))
- O SCENARIO DEVELOPMENT AND SCREENING (90% COMPLETE; LETTER REPORT (12/88), NUREG/CR (9/88 DRAFT))
- O SOURCES OF DATA AND PARAMETER UNCERTAINTY (35% COMPLETE; LETTER REPORT (8/88), NUREG/CR (8/88 (DRAFT), 6/89, 9/89)

## TASK ON PROBABILITIES OF DISRUPTIVE EVENTS AND PROCESSES

- O LITERATURE REVIEW OF QUANTITATIVE TECHNIQUES FOR ESTIMATING PROBABILITIES OF EVENTS AND PROCESS THAT MAY DISRUPT HLW REPOSITORY PERFORMANCE (COMPLETE; NUREG/CR (6/88 DRAFT))
- O RECOMMENDED TECHNIQUES FOR ESTIMATING PROBABILITIES OF EVENTS AND PROCESS THAT MAY DISRUPT HLW REPOSITORY PERFORMANCE (80% COMPLETE; NUREG/CR (1/89))

## NATURAL ANALOGUES OF HLW DISPOSAL SITES

DEFINITION: A NATURAL OCCURRENCE OF MATERIALS AND/OR PROCESSES THAT ARE ANALOGOUS TO EXPECTED MATERIALS AND/OR PROCESS IN A PROPOSED GEOLOGIC WASTE REPOSITORY. (ADOPTED BY THE NATURAL ANALOGUE WORKING GROUP OF THE COMMISSION OF EUROPEAN COMMUNITIES)

## WHY STUDY NATURAL ANALOGUES?

- o A GEOLOGIC REPOSITORY OF HLW IS A NATURAL, COMPLEX SYSTEM WITH A VERY LONG OPERATING LIFE.
- o NRC HAS TO HAVE REASONABLE ASSURANCE THAT PREDICTIONS OF HLW REPOSITORY PERFORMANCE OVER AT LEAST 10,000 YEARS ARE SUFFICIENTLY ACCURATE TO PROVIDE CONFIDENCE IN LICENSING DECISIONS ABOUT HLW DISPOSAL.
  - o LABORATORY EXPERIMENTS OFFER SHORT-TERM TESTS OF SELECTED, ISOLATED PROCESSES.
  - o FIELD EXPERIMENTS OFFER SHORT-TERM TESTS OF COMPLEX PROCESSES.
  - o NATURAL ANALOGUES OFFER LONG-TERM TESTS OF COMPLEX PROCESSES AND ARE THE ONLY AVAILABLE LONG-TERM EXPERIMENTS FOR TESTING MODELS OF HLW REPOSITORY PERFORMANCE.
- o ADVANTAGES OF NATURAL ANALOGUES ARE:
  - o LONG TIME SCALES
  - o LENGTH SCALES COMPARABLE TO REPOSITORY LENGTH SCALES
  - o RECORDS OF COMPLEX, COUPLED PROCESSES
  - o LONG-TERM AND LARGE-SCALE DATA FOR VALIDATION OF MODELS THAT HAVE BE APPLIED TO LONG TERMS AND LARGE SCALES
  - o CHECKS ON SITE CHARACTERIZATION

BASIS FOR PUBLIC CONFIDENCE IN MATHEMATICAL MODELS APPLIED

### WHY SHOULD NRC STUDY NATURAL ANALOGUES?

- o 10 CFR 60.21 REQUIRES THAT DOE USE NATURAL ANALOGUES TO SUPPORT PREDICTIONS OF HLW REPOSITORY PERFORMANCE; NRC HAS TO UNDERSTAND WHETHER DOE HAS USED NATURAL ANALOGUES PROPERLY
- o NRC NEEDS ITS OWN BASIS FOR CONFIDENCE IN PERFORMANCE ASSESSMENTS THAT IT USES IN ASSESSING DOE'S LICENSE APPLICATIONS

WHY STUDY NATURAL ANALOGUES NOW?

- O PROVIDE A BASIS FOR MODEL VALIDATION BEFORE HLW LICENSING DECISIONS HAVE TO BE MADE
- O EARLY RESOLUTION OF PERFORMANCE ISSUES (PRIOR TO LICENSING)

### WHY VALLES CALDERA NATURAL ANALOGUE?

THE VALLES CALDERA NATURAL ANALOGUE IS THE ONLY ONE AVAILABLE TO NRC THAT IS IN UNSATURATED TUFFS THAT ARE IN MANY WAYS SIMILAR TO THE YUCCA MOUNTAIN TUFFS.

NRC-SUPPORTED NATURAL ANALOGUE  
RESEARCH AT SANDIA

"A NATURAL ANALOGUE FOR A HIGH-LEVEL WASTE REPOSITORY:  
CHEMICAL MIGRATION AND THERMAL EFFECTS IN THE VC-1 COREHOLE,  
VALLES CALDERA, NEW MEXICO"

OBJECTIVES: 1) TO TEST ABILITY OF SHORT-TERM LABORATORY  
EXPERIMENTS TO PREDICT OBSERVED MINERALOGICAL ALTERATION IN  
THE VICINITY OF A NATURAL HEAT SOURCE; 2) TO DETERMINE THE  
EXTENT AND MEANS OF ELEMENTAL TRANSPORT IN HEATED ROCK IN  
RESPONSE TO A HEAT SOURCE.



TASKS AND THEIR STATUS IN  
THE NATURAL ANALOGUE PROJECT

- O WHOLE ROCK ANALYSES OF MAJOR TRACE ELEMENTS ANALOGOUS TO FISSION PRODUCTS (Na, K, Ca, Al, Si, Fe, H<sub>2</sub>O, Cl ions, Cs, U, Th, Ta, Sb, Sr, etc.) (60% COMPLETE; NUREG/CR (6/89))
- O CHARACTERIZATION OF ALTERATION PHASES TO ESTABLISH MINERALOGICAL CHANGES (40% COMPLETE; NUREG/CR (1/90))
- O THERMAL MODELING (CONDUCTION VS CONVECTION) (40% COMPLETE; NUREG/CR (1/91))
- O PALEOGEOTHERMS, AGES OF DEPOSITION (ISOTOPIC ARGON AGES TO INDICATE ROCK SOLIDIFICATION TEMPERATURES) (60% COMPLETE; NUREG/CR (6/89))
- O EXPERIMENTAL STUDIES (EVALUATION OF SHORT-TERM LABORATORY EXPERIMENTS TO PREDICT LONG-TERM PROCESSES; MOBILIZATION OF TRACE ELEMENTS IN CLOSED, OPEN, AND REFLUX SYSTEMS) (35% COMPLETE; NUREG/CR (9/90))
- O SYNTHESIS OF RESULTS AND GEOCHEMICAL MODELING (COMBINING RESULTS OF CHEMICAL ANALYSES, OTHER LABORATORY EXPERIMENTS, AND THERMAL MODELING TO OBTAIN A CONSISTENT PICTURE OF THE EVOLUTION OF THE NATURAL ANALOGUE) (30% COMPLETE; NUREG/CR (1/91))