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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES
Washington Office

MEETING REPORT

December 8, 1992

SUBJECT: Nuclear Safety Research Review Committee (NSRRC), Waste Subcommittee Meeting (20-3702-071)

DATE and PLACE: December 1, 1992, Crowne Plaza Hotel, Rockville, MD

AUTHOR(S): John L. Russell

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SUBJECT: Nuclear Safety Research Review Committee (NSRRC), Waste Subcommittee Meeting

DATE and PLACE: December 1, 1992, Crowne Plaza Hotel, Rockville, MD

PERSONS PRESENT: The meeting was open to the public. The following list does not include all attendees.

NRC RESEARCH
G. Sege
B. Morris
M. Silberberg
W. Ott
J. Randall
J. Philip
P. Reed
E. O'Donnell
T. McCartin
T. Nicholson
G. Birchard
L. Kovach

NRC NMSS
B. Youngblood
M. Federline
R. Johnson
N. Eisenberg

CNWRA
J. Russell

NSRRC
F. Molz (Chairman)
S. Bernstein
H. Isbin
E. Kinter
D. Turcotte
R. Vogel

BACKGROUND AND PURPOSE:

The Waste Subcommittee of the Nuclear Safety Research Review Committee (NSRRC) conducted a one-day meeting to receive overviews by NRC staff of the NRC's high-level nuclear waste (HLW) geologic repository performance assessment (PA) program and NRC's HLW research program, exclusive of work on the engineered barrier system. This meeting represented the first meeting of the Waste Subcommittee subsequent to November, 1992.

SUMMARY OF PERTINENT POINTS:

All members of the NSRRC Subcommittee were present at the subject meeting with the exception of Dr. Thomas Boulette. The agenda for the meeting and copies of presentation materials (printed copies of overhead transparencies) distributed during that meeting are attached to this report. These materials summarize well the major items discussed by NRC staff members during their respective presentations to the Subcommittee. Pertinent points not given in the presentation materials including synopses of certain discussions ensuing from questions and comments by subcommittee members are summarized below.

In response to questions on the NRC's PA program, NRC staff commented that approximately one-third of the work in this area is being conducted respectively at CNWRA, NRC Office of Research (RES), and NRC Division of High-Level Waste Management (DHLWM). It was noted by the staff that iterative performance assessment (IPA) Phases I and II stressed the development of staff capabilities.

Concern was expressed by several Subcommittee members that data from site characterization was not adequate at present to give confidence in modeling results. Great uncertainty in data may prevent understanding of the "driving forces" which may affect PA calculations. The topic of validation was also discussed including a question on what data set could be used to validate the entire PA system code and what would be the role of Natural Analogs in validation. A response was that certain modules can be validated but it was probable the entire system code can not be validated considering the large time and space scales involved. Participation in INTRAVAL was given as an example of an NRC activity to stay at the leading edge of international work on validation of hydrologic transport codes.

Several questions were made by Subcommittee members on the relation between precipitation and infiltration and consideration of these as steady state or transient conditions in hydrologic modeling. The relationship of these conditions to potential climatic changes was discussed and NRC support of research by the National Science Foundation and by Brown University on climatic change was noted by the NRC staff.

An overview of the hydrologic and hydrogeochemical research at the Apache Leap Site by the University of Arizona resulted in comments by Subcommittee members who noted the desirability of determining total volumetric flow of groundwater into the Magma Mine haulage tunnel instead of only determining flow from several discrete fractures. The NRC staff replied that modeling of the entire water budget and flow system is not being conducted in the project.

The NRC staff presentation of research on volcanism was accompanied by questions by Subcommittee members regarding why the staff believed the research approach being used will be successful, whether other groups are developing predictive models of volcanic events, and why this type of research is within NRC's role. The staff noted that it was within the NRC's role and that the data on volcanism to give sound prelicensing guidance and to make licensing decisions had not been compiled and assessed. It was also noted that the mechanisms driving potential volcanism at the Yucca Mountain Site area should be investigated on a regional scale by the NRC.

In regard to NRC staff's presentation on CNWRA's geochemistry program, subcommittee members questioned why much of the research involved the use of uranium, and questioned the validity of using it as a general proxy for the actinides. The staff noted there will be a large inventory of uranium in the system and there is a need to understand its behavior in addition to potential use as a proxy for other radionuclides.

An extensive discussion ensued from the NRC staff's presentation of thermohydrologics [thermohydrology] research at the CNWRA. The discussion involved aspects of experimental design, behavior, and definition of goals (e.g.,

determination of what phenomena the experiments were attempting to "elucidate"). Mr. Sol Bernstein requested through Dr. Molz, the chairman, that the Subcommittee receive additional information on thermohydrology research at CNWRA including the comments generated on the research by the peer review exercise.

In closing, members of the Subcommittee noted the great difficulties that commonly exist when integrating the large number of technical disciplines involved in the HLW program. They also noted the evolution and uniqueness of developing PA capabilities at the NRC within the context of conflict of interest considerations and development of CNWRA.

SUMMARY OF ACTIVITIES:

The author's activities consisted of attending the NSRRC Waste Subcommittee meeting to obtain the information contained in this report.

IMPRESSIONS/CONCLUSIONS:

The Waste Subcommittee will prepare a report on the subject meeting for presentation to the full NSRRC at its planned January, 1992 meeting. Professor Molz requested comments for the report from Subcommittee members and from "anyone else." Limited duration of the subject meeting and the infrequent reoccurrence of Subcommittee meetings prevented detailed presentation and discussion of the entire breadth of activities in the NRC's HLW PA and RES programs.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

The Waste Subcommittee's meeting written report and oral presentation to the full NSRRC must be reviewed by the CNWRA and appropriate action taken as deemed necessary. This Subcommittee should be among the recipients of the forthcoming NUREG/CR on the Thermohydrology Project.

AUTHOR: DATE: _____

_____

John L. Russell

Attachments

rec'd with letter dtd 12/18/92

Presentation for the
Nuclear Safety Research
Review Committee

Iterative Performance Assessment

by
Norman A. Eisenberg
December 1, 1992

426.1

Mission Differences Cause Differences in Scope between NRC & DOE Activities

- DOE responsible for determining site suitability through adequate characterization
- DOE develops methods to demonstrate compliance; provides data and analyses to NRC
- NRC & DOE interact during pre-licensing development of the repository
- NRC evaluates DOE's demonstration of compliance
- NRC needs an independent understanding of repository performance
- NRC Research program provides needed understanding

NRC Organizations With PA Missions

Organization	Mission
NMSS	•Licensing, inspection, and regulation of DOE HLW program •Develops regulatory policy & guidance
RES	•Develops, plans, and manages waste management research •Develops rules and standards
CNWRA	•FFRDC conducting research and technical assistance for RES and NMSS

NRC Performance Assessment Activities

1. REACTIVE WORK
   - responds to DOE products and activities

2. PROACTIVE WORK
   - NRC Initiated:
     independent PA capability
     develop guidance for DOE
     program integration
     contributes to sytematic analysis of regulations

3. REGULATORY RESEARCH PROGRAM

4. PARTICIPATION IN INTERNATIONAL ACTIVITIES

Performance Assessment

Performance assessment is a type of systematic safety analysis used to:

- predict the potential health, safety, and environmental effects of creating and using a nuclear waste repository;
- characterize these effects in terms of their magnitudes and likelihoods;
- compare the characterization of these effects to acceptability standards; and
- present the results of these analyses in a format useful to regulators, scientists, decision-makers and the public.

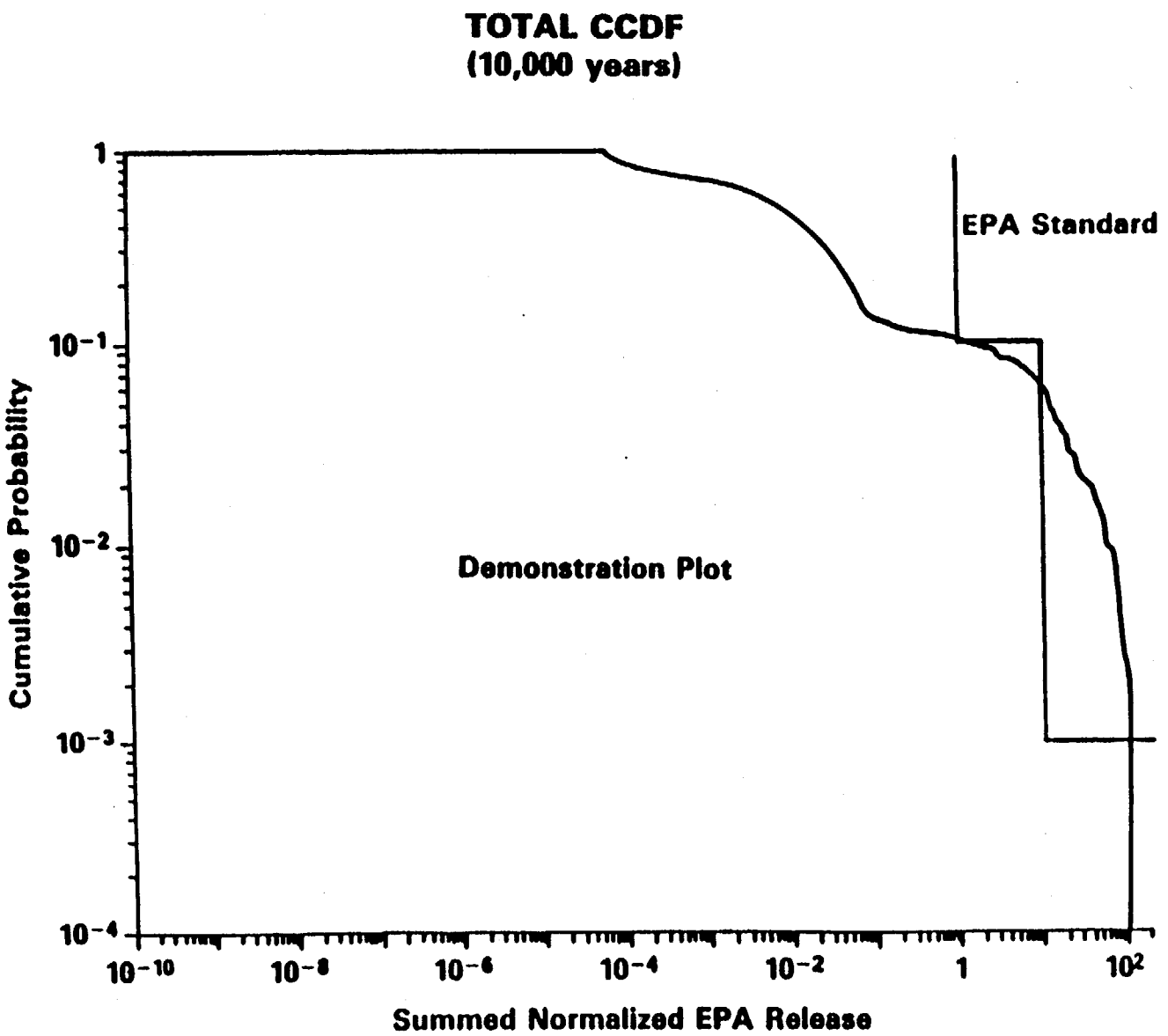
QUANTITATIVE PERFORMANCE REQUIREMENTS FOR HIGH-LEVEL WASTE REPOSITORIES

U.S. Environmental Protection Agency

- Cumulative releases over 10,000 years to the accessible environment not to exceed specified limits for specified radionuclides
- Groundwater protection requirement at 1,000 years.
- Individual protection requirement at 1000 years.

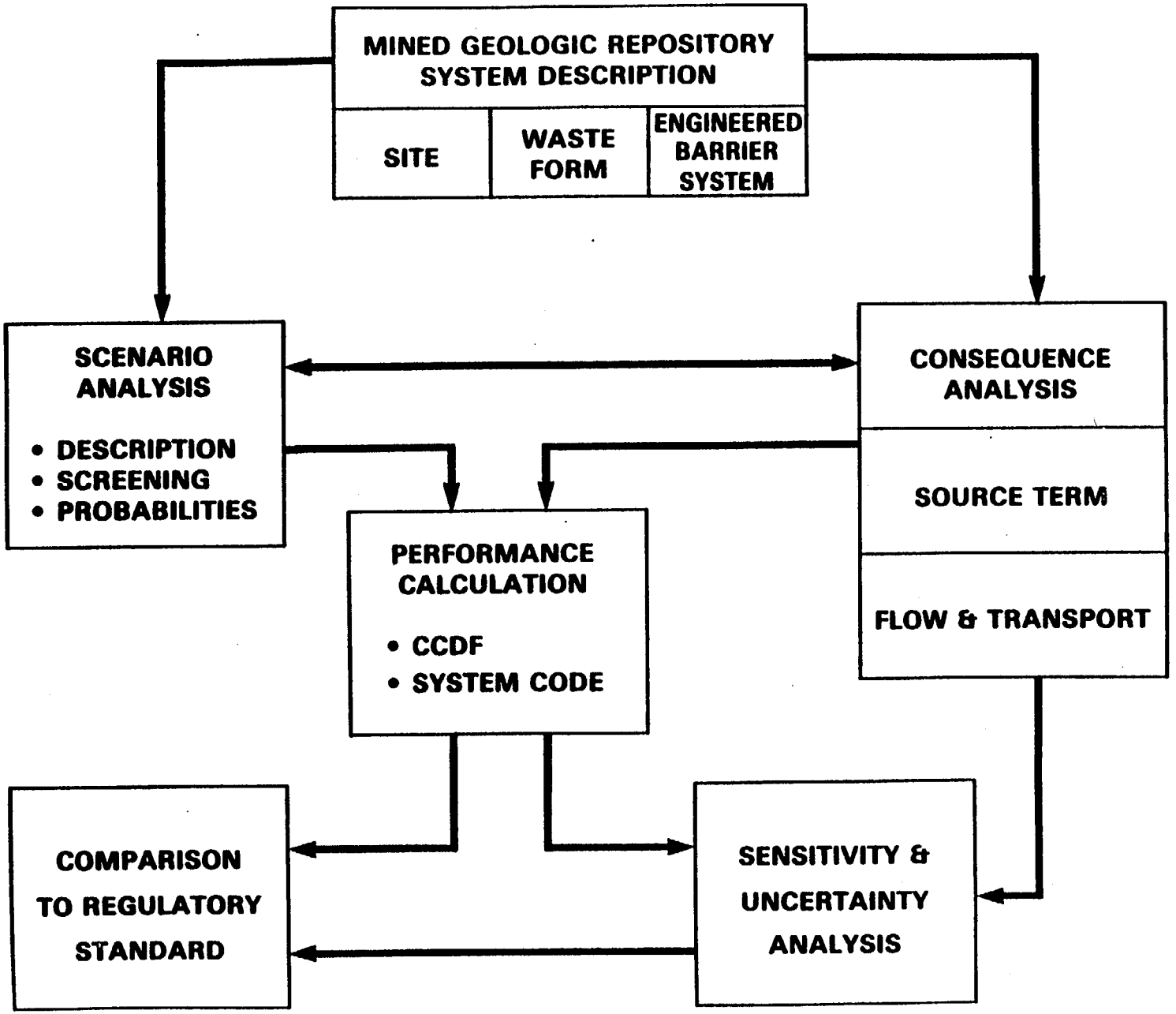
U.S. Nuclear Regulatory Commission

- Substantially Complete containment of radionuclides within the waste package for 300 to 1000 years.
- Annual release of individual radionuclides shall not exceed 10^{-5} of their 1,000 year inventory.
- The fastest water travel time from the repository to the accessible environment shall be more than 1,000 years.


TOTAL CCDF
(10,000 years)
EPA Standard
Demonstration Plot
Cumulative Probability
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
10^{2}
Summed Normalized EPA Release

ATTRIBUTES OF PERFORMANCE ASSESSMENT

- Quantitative
- Magnitude and Likelihood Considered
- Directed to Regulatory Requirements



Components of a total system performance assessment.

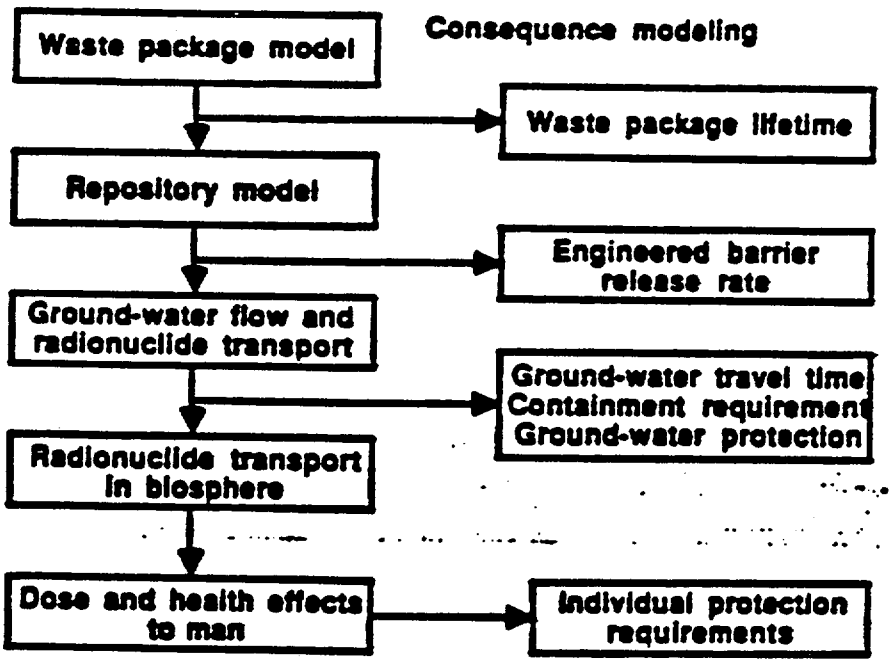


Fig. 1. Illustration of consequence modeling sequence showing points of compliance assessment with EPA and NRC regulations.

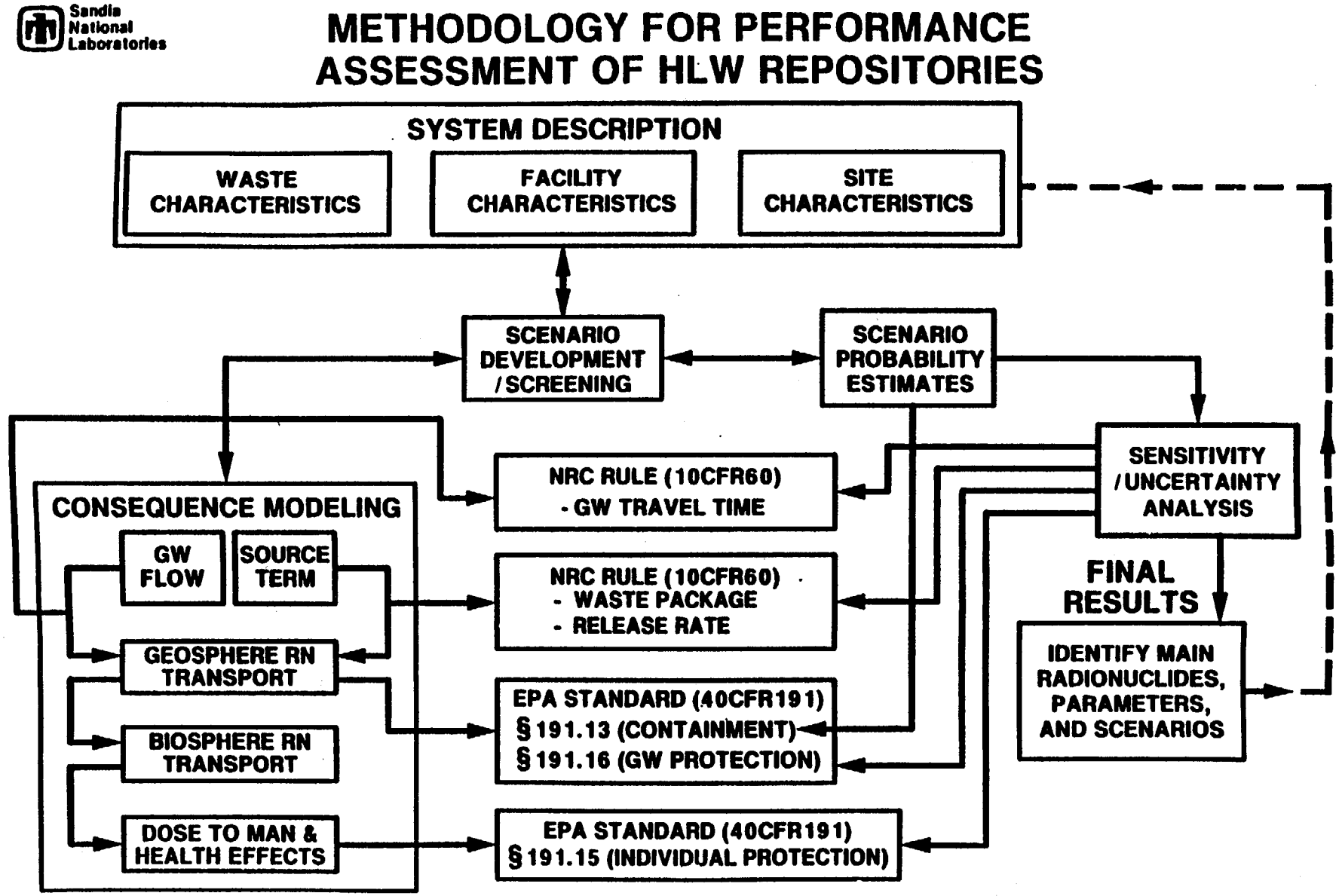


Figure 3.1. Flowchart for SNL Performance Assessment Methodology

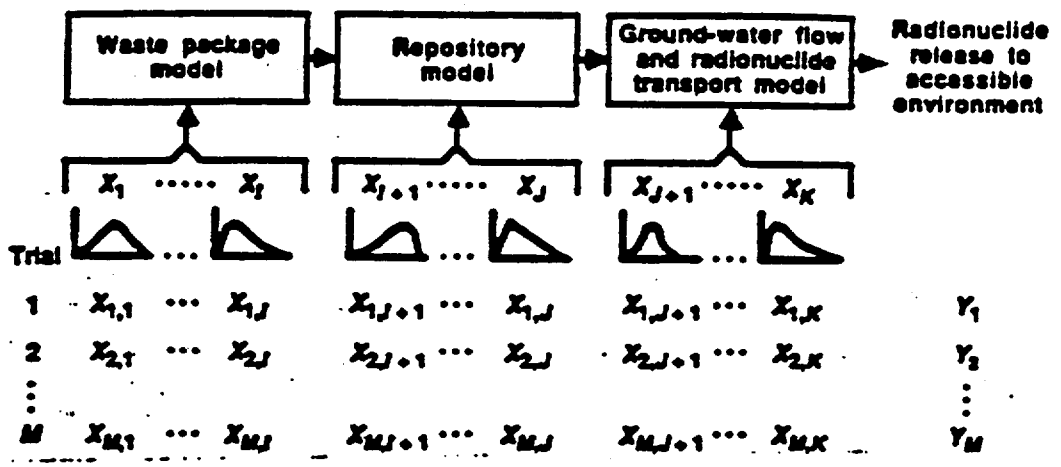


Fig. 3. Illustration of the use of statistical sampling to treat data uncertainties in consequence modeling. The first I variables are used in the waste package model. Variables $I + 1$ through J are used in the repository model, and variables $J + 1$ through K are used in the ground-water flow and radionuclide transport model.

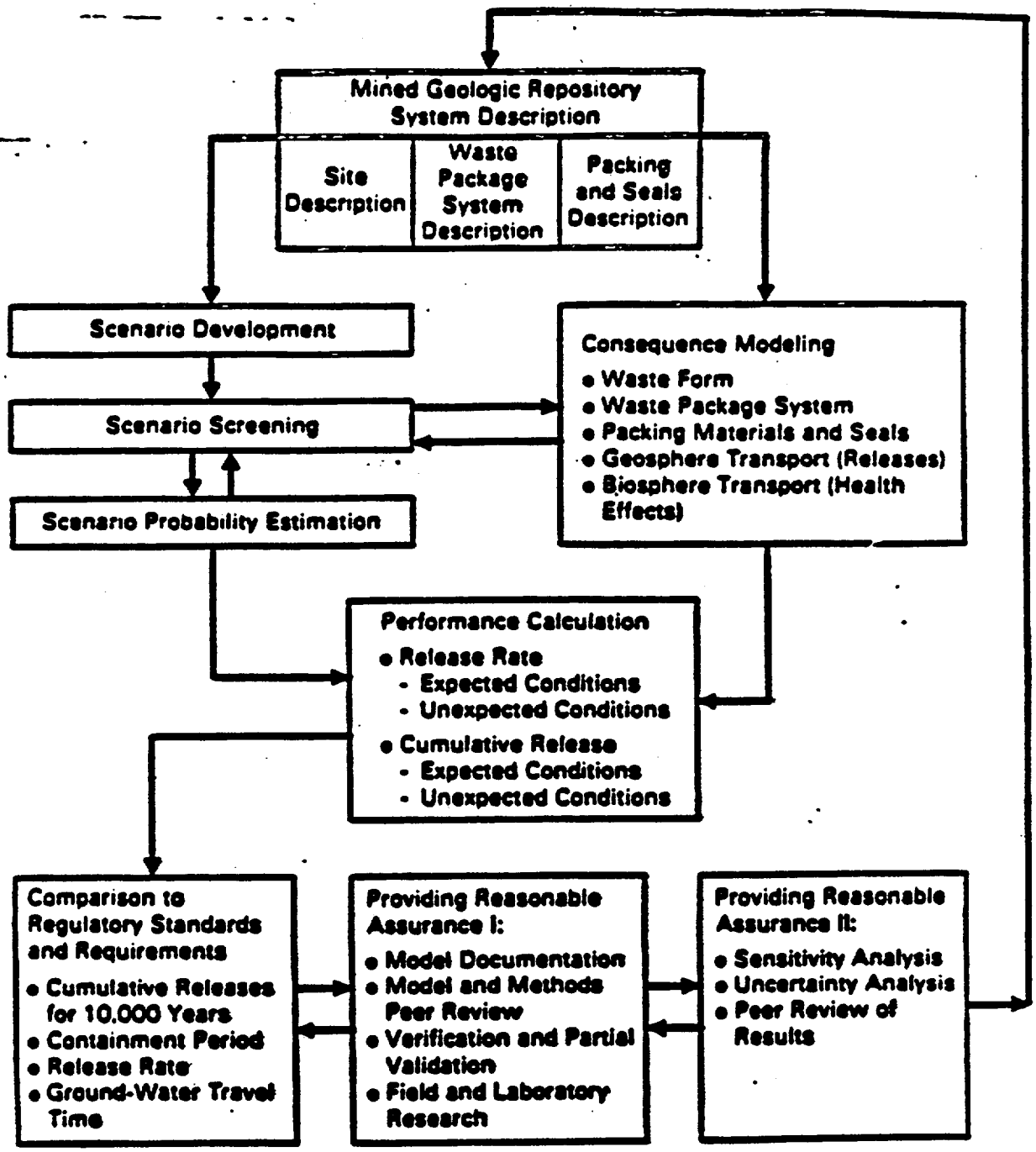
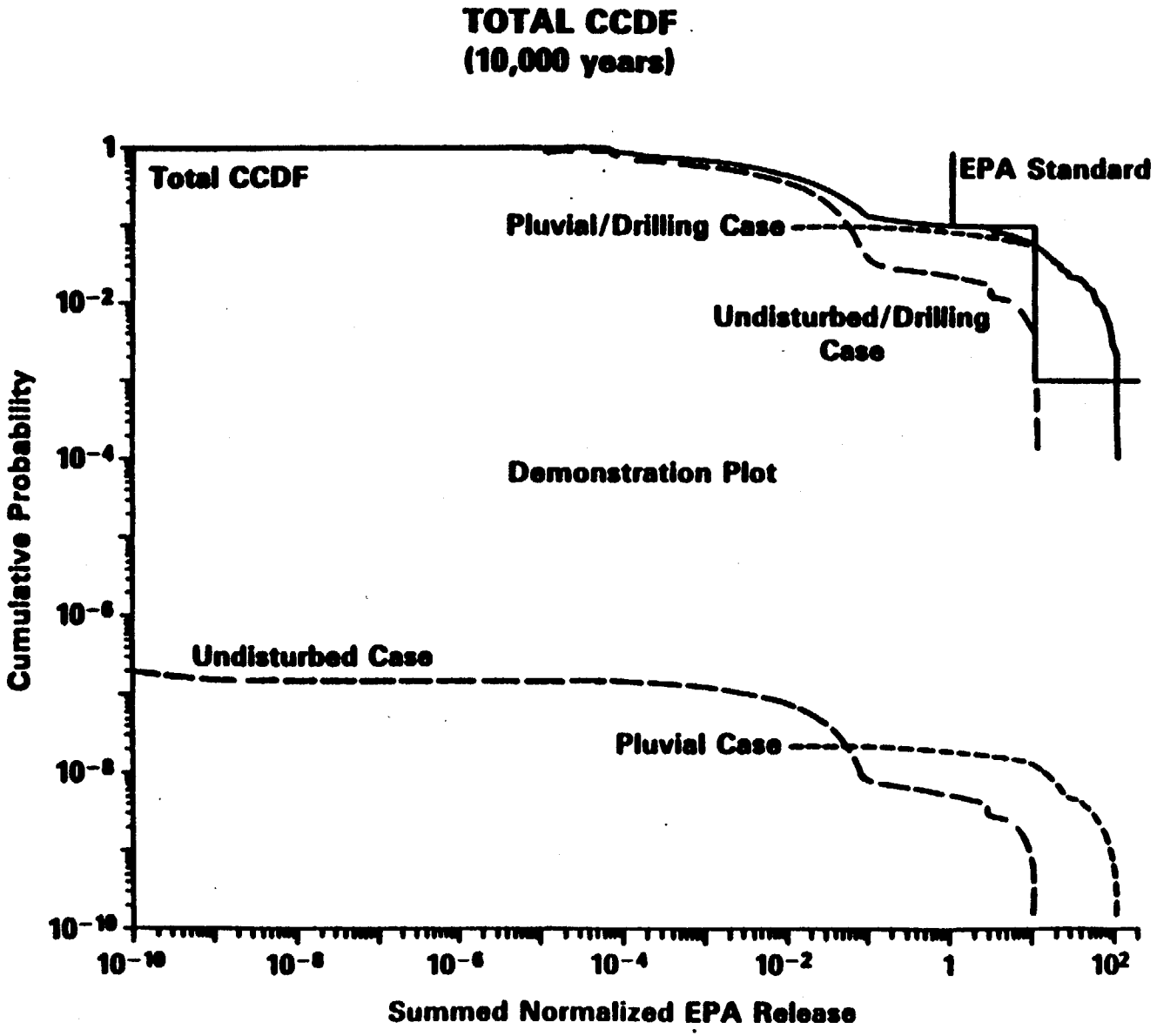


FIGURE 1. COMPONENTS OF THE STRATEGY FOR ASSESSING THE POSTCLOSURE PERFORMANCE OF THE GEOLOGIC REPOSITORY SYSTEM


TOTAL CCDF
(10,000 years)
Total CCDF
EPA Standard
Pluvial/Drilling Case
Undisturbed/Drilling Case
Demonstration Plot
Undisturbed Case
Pluvial Case
Cumulative Probability
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
10^{2}
Summed Normalized EPA Release

TWO COMPONENTS OF PERFORMANCE ASSESSMENT

- Quantitative Estimates of Performance
- Auxiliary Analyses
  - Evaluate assumptions
  - Determine parameter values
  - Detailed models to support simplified PA models

ITERATIVE PERFORMANCE ASSESSMENT

- Develop NRC Capability
- Review DOE's IPA's
- Advantages:
  - Finds weakness in methods
  - Finds weakness in data
  - Builds concensus
  - Defines critical issues
    - Licensing
    - Research Needs
  - Focuses on regulatory compliance
  - Continual evaluation of Site Characterization

IPA
BENEFITS

- Ongoing NRC evaluation of DOE site characterization
- Ongoing NRC evaluation of HLW regulations
- Technical input to development of NRC staff positions
- Identification of Key Technical Uncertainties; Helps to:
  - Define Research Needs
  - Establish Priorities

NRC REVIEW OF PA IN DOE's LA

NRC will review the performance assessment in the DOE license application

- Review entire performance assessment at a broad level
- More detailed review of significant areas
- IPA & SRA will indicate areas for verification by independent NRC quantitative analysis
- At least one rough quantitative check on overall performance estimate

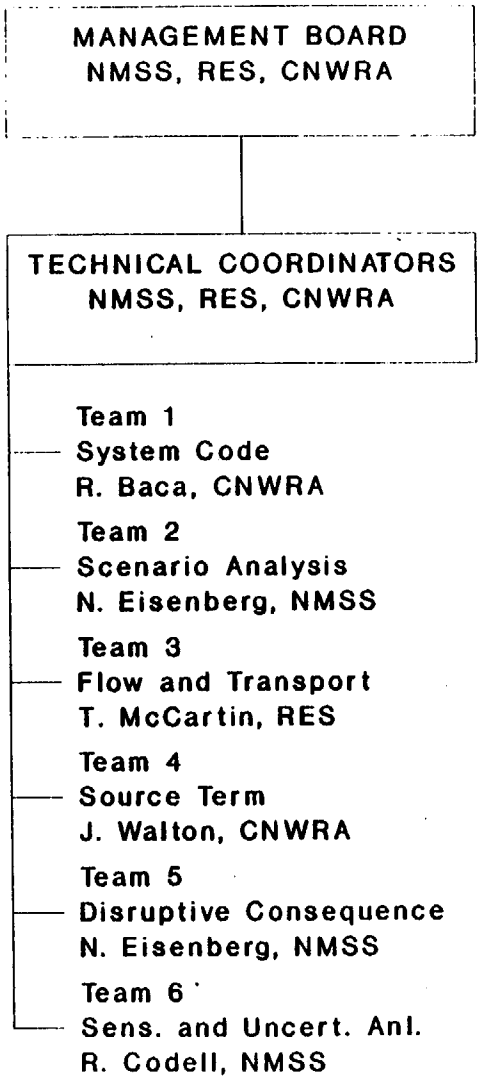
AUXILIARY ANALYSES WILL PROVIDE BASES TO EVALUATE ALTERNATIVES TO:

- CONCEPTUAL MODELS
- PROCESS MODELS
- PARAMETER VALUES
- SENSITIVITY ANALYSES

SPECIAL ATTENTION TO UNCERTAINTIES IN ASSUMPTIONS REGARDING:

- CONCEPTUAL MODELS
- FUTURE STATES OF NATURE (SCENARIOS)
- ESTIMATES OF PARAMETER VALUES

IPA ORGANIZATION



IPA
Overall Objective

"...to develop, maintain, and enhance the NRC staff capability to review effectively performance assessment in the DOE License Application for a HLW repository."

IPA Phase 2
Additional Objectives

- Ongoing NRC evaluation of DOE site characterization
- Ongoing NRC evaluation of HLW regulations
- Technical input to development of:
  - NRC staff positions
  - other regulatory products (LARP)
  - HLW Research Program

IPA Phase 2
Special Objective

- Provide for a smooth transition of contractual support from SNL to the CNWRA
- Evaluate the tuff methodology prepared by SNL

IPA Phase 2 Accomplishments

Achievement	Status
1. Develop Internal Mode System Code (Executive Module)	Done
2. Add Dose Assessment Capabil.	Done
3. Evaluate 60.113 Impact on EPA Standard Compliance	Limited analysis planned
4. Evaluate SNL Scenario Meth.	Done
5. Provide Scenarios and Prob. for Total System PA	Analysis Done, numbers soon
6. Develop Gas Transport Model	Done

IPA Phase 2
Accomplishments (2)

Achievement	Status
7. Develop Overall Source Term Model and Computer Code	Done
• Waste Package Failure (Corrosion & Stress Mech.)	Done
• Waste Form Dissolution & Near-field Transport	Done
• Gas-phase Source Term	Done
8. Provide Capability to Model Additional Scenario Classes	Done
9. Sensitivity and Uncertainty Analysis	Turnkey system now under test

Enhancements Added in Phase 2 IPA

- "Internal Mode" System Code
- Dose Assessment Capability Added
- Evaluation of SNL Scenario Methodology
- 16 Scenario Classes
- More refined modeling of flow and transport in unsaturated fractured rock
- Gaseous Transport Pathway Added
- Saturated Zone Transport Added

Enhancements Added in Phase 2 IPA

- Improved Treatment of Source Term
  - Mechanistic Waste Package Failure
  - Improved Waste Dissolution/Transport Model
  - Gaseous Phase Source Term
- Treatment of Several Disruptive Scenario Classes
- Turnkey Sensitivity and Uncertainty Analysis
- Higher Spatial Resolution: 7 Repository Regions and Corresponding Geosphere Transport Legs

Continued

Auxiliary Analyses in Phase 2 IPA

- Carbon-14 Analysis
- Applicability of KD's
- Effects of Layering and Dipping
- USGS Regional Modeling
- Saturated Regional Modeling
- 2-D Unsaturated Modeling
- Colloid Formation Modeling
- Source-Term for Magmatic Events
- Comparison of Sensitivity and Uncertainty Methods

Things
TO BE DONE

- continue testing all modules in TPA
- test sens. & uncert. turnkey system
- document auxiliary analyses
- production runs
- sensitivity and uncertainty analyses
- document results
- edit to first draft for management
- DOE Tech. Exch. and ACNW WG Meeting

PERFORMANCE ASSESSMENT RESEARCH NEEDS

701 **Scenario Analysis**

- Evaluation of safety system analysis methods for scenario identification
- Evaluation of "scenario method" vs. "environmental simulation method"
- Scenario screening

702 **System Code Efficiency**

- Improve computational efficiency of modules
- Explore methods for module simplification
- Improve computational techniques for coupled processes
- Explore innovative solutions to interface problems

703 **Validation**

- Evaluate and develop methods for model validation and verification

Progress in Natural Analogs Research

Presented to the
Nuclear Safety Research Review Committee
1 December 1992

Presented by
Linda A. Kovach
USNRC Office of Research
tel. (301) 492-3869

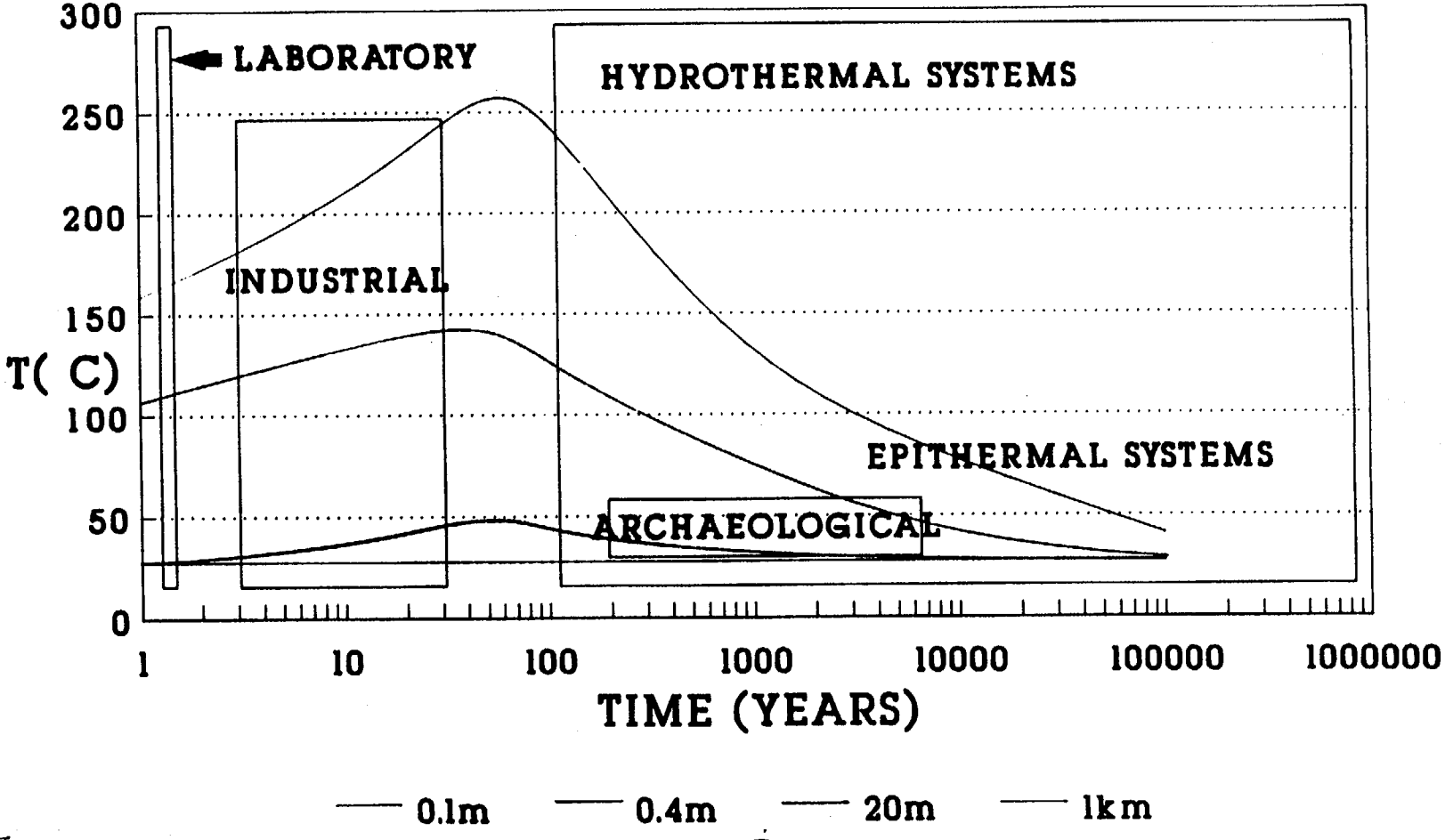
Natural Analogs Research

Regulatory Bases:

10 CFR 60.21(c)(1)(ii)(F)
Predictive Models ...in License Applicant's Safety Analysis Report shall be supported by **Appropriate** use of ... Field Tests, In Situ tests and **Natural Analog** Studies.

10 CFR 60.101(a)(2)
Demonstration of Compliance with Objectives and Criteria for ... repository performance over **Long Times** ... will involve the use of performance models supported by such measures as **Natural Analog** Studies.

APPLICABILITY OF CATEGORIES OF ANALOGS VERSUS TIME-TEMPERATURE OF REPOSITORY



Time-Temperatures from K. Pruess LBL

Application of Natural Analogue Studiesto Nuclear Waste Disposal Licensing Process

"Reality testing" of Assumptions:

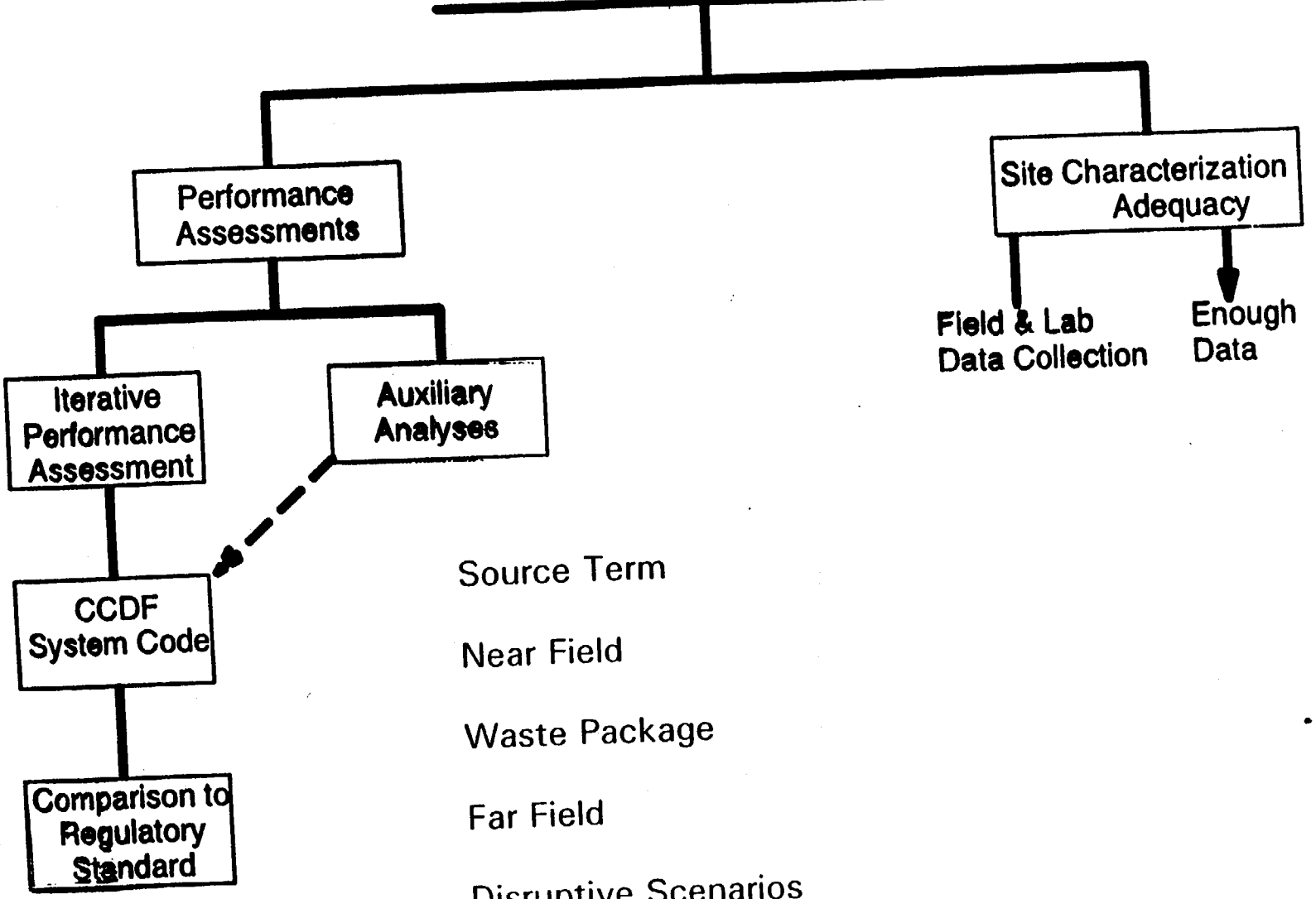
- Performance Assessments
- Site Characterization

Performance Assessment - Auxiliary Analyses

"Reduce Uncertainty - Gain Confidence"

- Conceptual Models
- Auxiliary Computer Codes
- Range of Input Parameters
- Exercise PA teams - "Trial Runs"

LICENSING PROCESS



CURRENT NRC NATURAL ANALOGUE STUDIES

HYDROLOGIC CONDITIONS	WASTE FORM SOURCE TERM	WASTE PACKAGE	HOST ROCK STABILITY	TRANSPORT
SATURATED	ARAP PENA BLANCA OKLO		PENA BLANCA OKLO	ARAP OKLO
UNSATURATED	PENA BLANCA ARAP	SANTORINI	VALLES CALDERA PENA BLANCA	VALLES CALDERA ARAP PENA BLANCA SANTORINI

ELEVATED TEMPERATURES, TIME > 100 YEARS

ARAP — Alligator Rivers Analogs Project

Application of ARAP studies

"Reduce Uncertainty - Gain Confidence"

Geochemical Modelling:

- Testing & Developing Thermodynamic Databases

Radionuclide Migration/Retardation

- Develop & Test mechanistic U-sorption models
- Geochemistry of ^{239}Pu, ^{129}I, ^{99}Tc, and ^{36}Cl

Regulatory Perspective

Contributions from ARAP

- Identified inconsistencies in thermodynamic database
- Corrections to thermodynamic database
- Developed more sophisticated models for U sorption
- Tested various computer models
- Tested site characterization methodology

Natural Analogs Research

Geochemical Natural Analogs Research Project - CNWRA

Task 1: Literature Review and Identification of Potential Sites

Task 2: Site Selection

Source Term:	Pena Blanca
Contaminant Transport:	Pena Blanca, Santorini
Container degradation:	Santorini

Task 3: Data Acquisition - Continuing

	Pena Blanca
	Santorini

Task 4: Interpretation of Data and Modeling - Continuing

Source Term:	Pena Blanca
Contaminant Transport:	Pena Blanca, Santorini
Container Corrosion:	Santorini

GEOCHEMICAL NATURAL ANALOG RESEARCH PROJECT

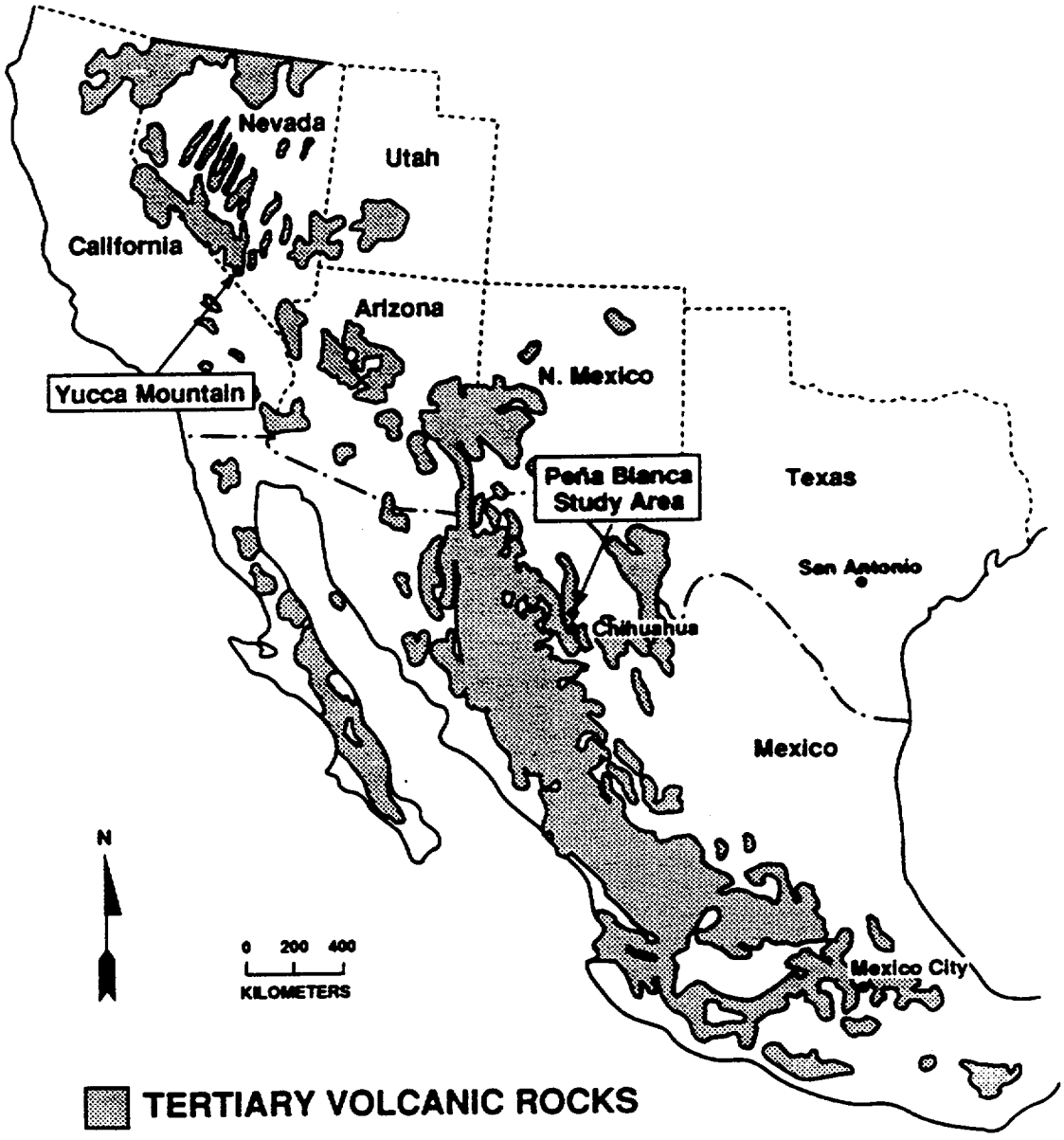
The Peña Blanca Natural Analog

→ **Source Term Analog**

Oxidation of uraninite ≈ Spent fuel degradation
- **secondary phase sequence**
- **rate controlling steps**

→ **Contaminant Transport Analog**

Redistribution of ore elements ≈ Radionuclide transport
- **relative mobilities**
- **radioelement retardation mechanisms**


Nevada
Utah
California
Arizona
N. Mexico
Yucca Mountain
Peña Blanca
Study Area
Texas
San Antonio
Chihuahua
Mexico
N
0 200 400
KILOMETERS
Mexico City
TERTIARY VOLCANIC ROCKS

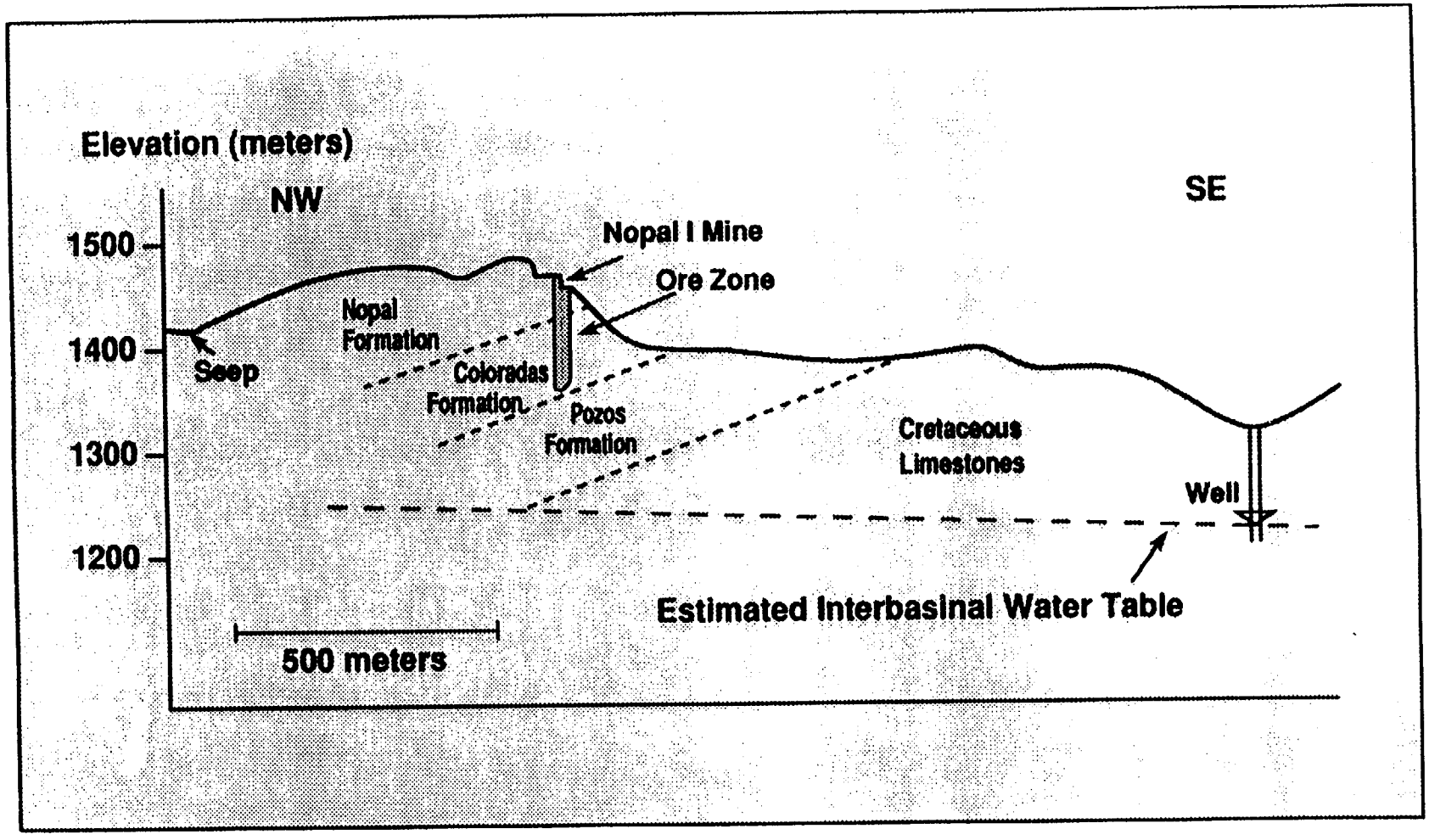

Elevation (meters)
NW
SE
1500
1400
1300
1200
Nopal I Mine
Ore Zone
Nopal
Formation
Seep
Coloradas
Formation
Pozos
Formation
Cretaceous
Limestones
Well
Estimated Interbasinal Water Table
500 meters

Table 7-1. COMPARISON OF THE CHEMICAL COMPOSITION OF THE NOPAL AND COLORADAS FORMATIONS AND THE TOPOPAH SPRING MEMBER OF THE PAINTBRUSH TUFF FORMATION (VALUES IN WEIGHT PERCENT)

Oxide	Nopal Formation	Coloradas Formation	Topopah Spring Member*
SiO_2	75.24	67.49	74.00
Al_2O_3	12.75	12.00	12.40
K_2O	6.48	4.13	4.00
Fe_2O_3	1.54	1.99	1.07
Na_2O	1.07	0.47	3.40
CaO	0.41	4.41	0.66
TiO_2	0.26	0.24	0.10
MgO	0.15	0.16	0.31
P_2O_5	0.07	0.04	0.01
MnO	0.06	0.11	0.08
LOI	2.60	8.17	3.79
Total	100.63	99.21	99.82

*Data from Broxton et al. (1986)
LOI = Loss on Ignition

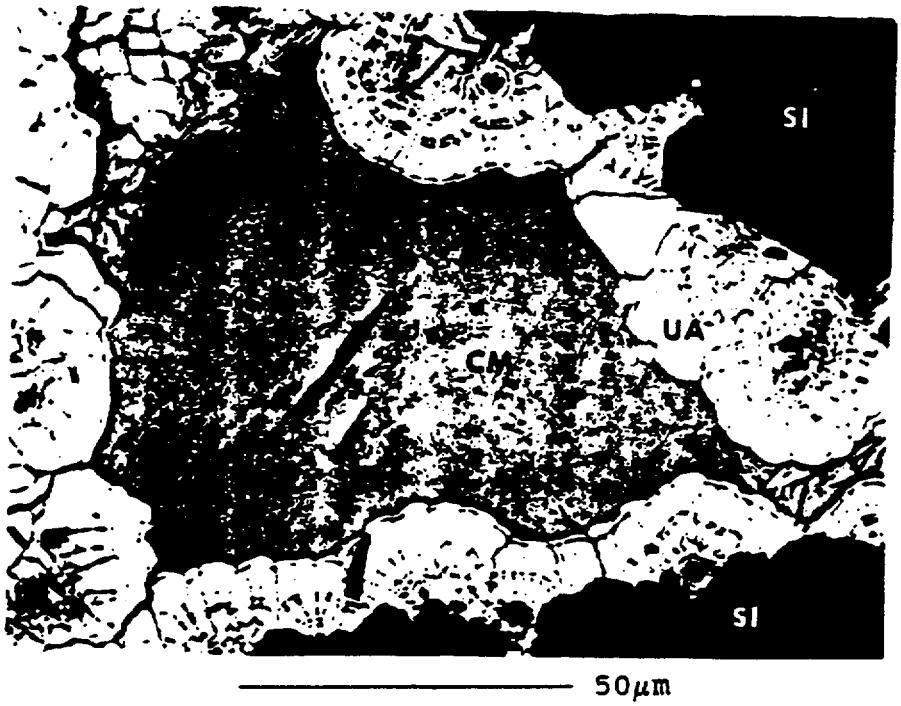


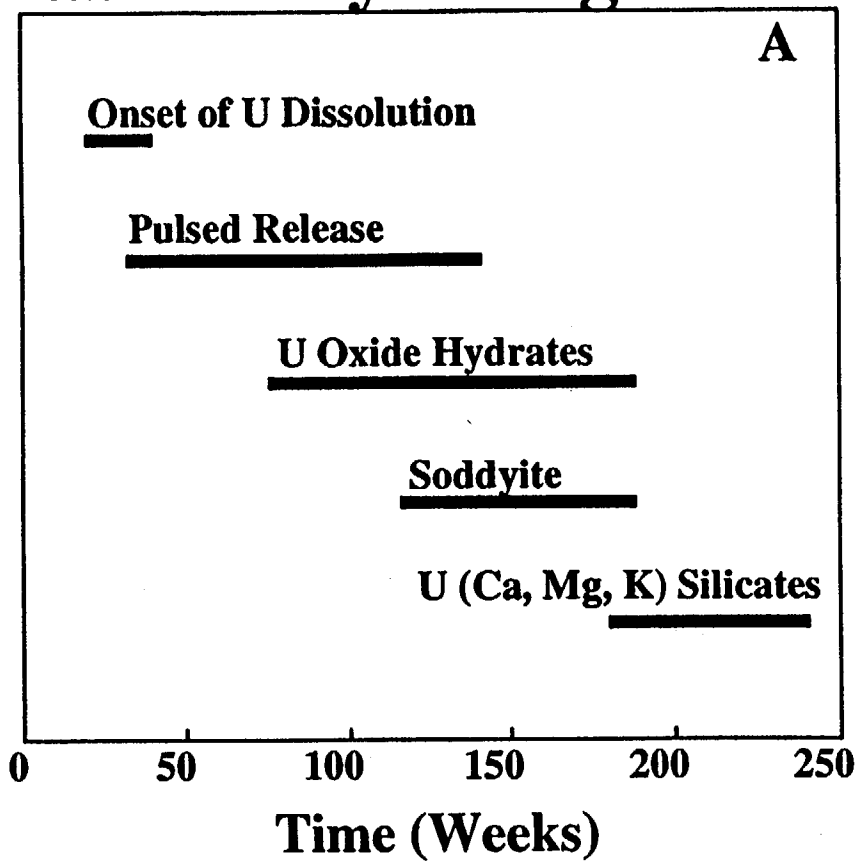
Figure 7-6. Backscattered electron photomicrograph of a polished thin section of U ore from Nopal I containing colloform uraninite (UA) lining a void between silicifed breccia fragments (SI). The center of the void is filled by soddyite (SO) and compreignacite (CM). Notice the radial and concentric microfractures in the uraninite along which the uraninite has been altered to soddyite.

Table 7-2. URANIUM MINERALS IDENTIFIED AT THE NOPAL I DEPOSIT

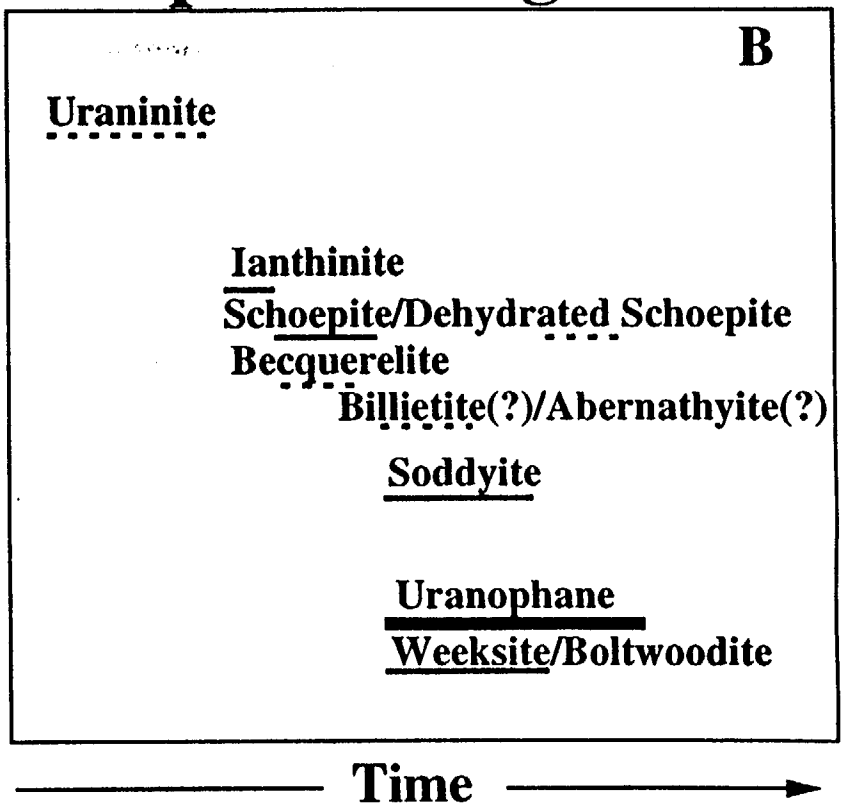
Mineral	Nominal Chemical Formula	Method of Identification
Uraninite	UO_{2+x}	OP, SEM/EDS, XRD, EMPA
Soddyite	$(UO_2)_2SiO_4 \cdot 2H_2O$	OP, SEM/EDS, XRD, EMPA
Uranophane	$Ca(UO_2)_2Si_2O_7 \cdot 6H_2O$	OP, SEM/EDS, XRD, EMPA
Weeksite	$K_2(UO_2)_2Si_6O_{15} \cdot 4H_2O$	OP, SEM/EDS
Boltwoodite	$KH(UO_2)SiO_4 \cdot 1.5H_2O$	OP, SEM/EDS
Compreignacite	$K_2(UO_2)_6O_4(OH)_6 \cdot 8H_2O$	OP, SEM/EDS, EMPA
Becquerelite	$Ca(UO_2)_6O_4(OH)_6 \cdot 8H_2O$	XRD
Ianthinite	$U^{4+}(U^{6+}O_2)_5(OH)_{14} \cdot 3H_2O$	OP
Schoepite	$UO_3 \cdot 2H_2O$	OP, SEM/EDS

OP = optical petrography
SEM/EDS = scanning electron microscopy/energy dispersive x-ray analysis
XRD = x-ray diffractometry
EMPA = electron microprobe analysis

Laboratory Paragenesis



Nopal I Paragenesis



Summary

- **Possible constraints on contaminant transport can be derived from the spatial distribution of U and U-series isotopic studies**

  1. Flow of U-bearing fluids was strongly influenced by fracture intensity, but flow was not limited to fractures.

  2. Remobilization of U occurred within the ore body, however, redistribution of U was primarily confined to the ore body.

  3. Preliminary ^{238}U decay-series measurements suggest secular equilibrium, indicating negligible transport under present analogous conditions.

- **Possible constraints on the source term can be derived from the sequence of formation of secondary uranium minerals**

  1. Uraninite → Uranyl Oxide Hydrates → Uranyl Silicates.

  2. Uranium concentrations (~ 2 ppm) in fluids possibly controlled by uranyl silicates solubilities.

The Akrotiri Natural Analog

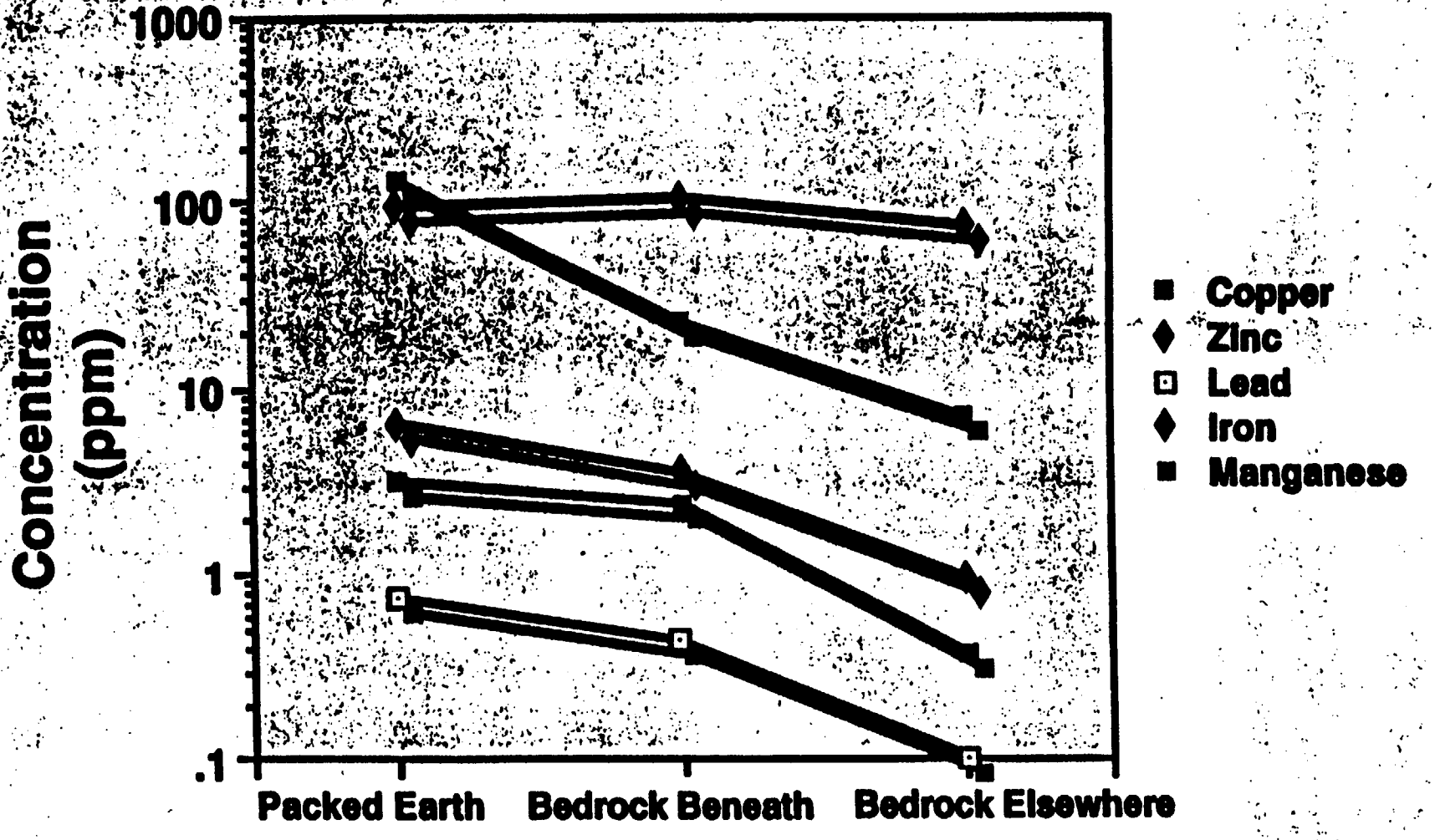
- Material Corrosion Analog:

  corrosion of metallic artifacts ≈ corrosion of HLW containers

- Contaminant Transport Analog:

  transport of elements from metallic artifacts ≈ radionuclide transport

Elemental Gradients at Akrotiri Delta 3

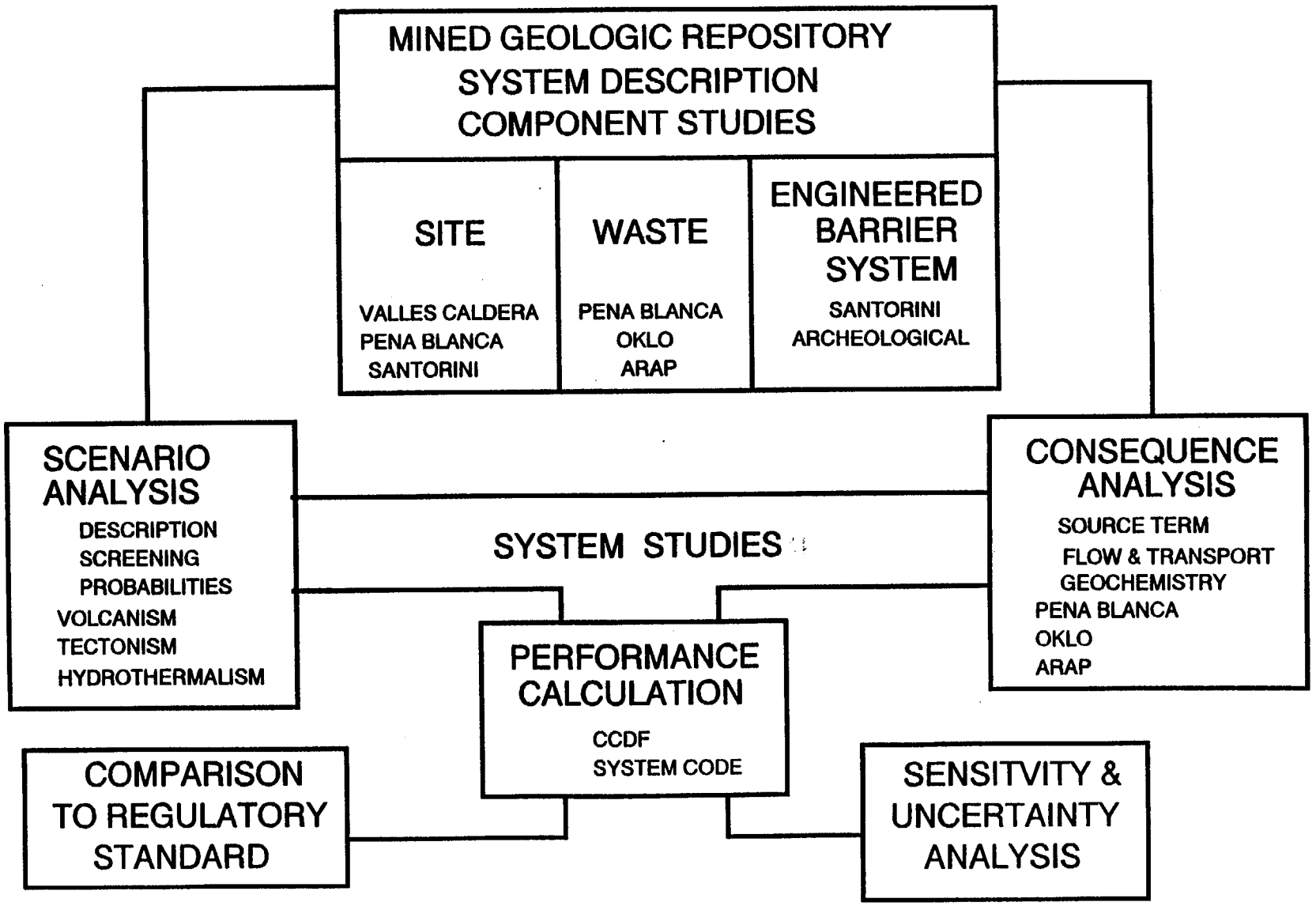


REGULATORY PERSPECTIVE

CONTRIBUTIONS FROM NATURAL ANALOGUES

- EXERCISE PERFORMANCE ASSESSMENT TEAMS
- IDENTIFIES AREAS OF CONFIDENCE AND WEAKNESS
- INTEGRATION OF DISCIPLINES/SITE CHARACTERISATION & PA
- OVERALL INTEGRATION OF PROJECT
- VALIDATION

COMPONENTS OF TOTAL SYSTEM PERFORMANCE ASSESSMENT



High-Level Waste

Performance Assessment

Presented to

NSRRC Waste Subcommittee

on December 1, 1992

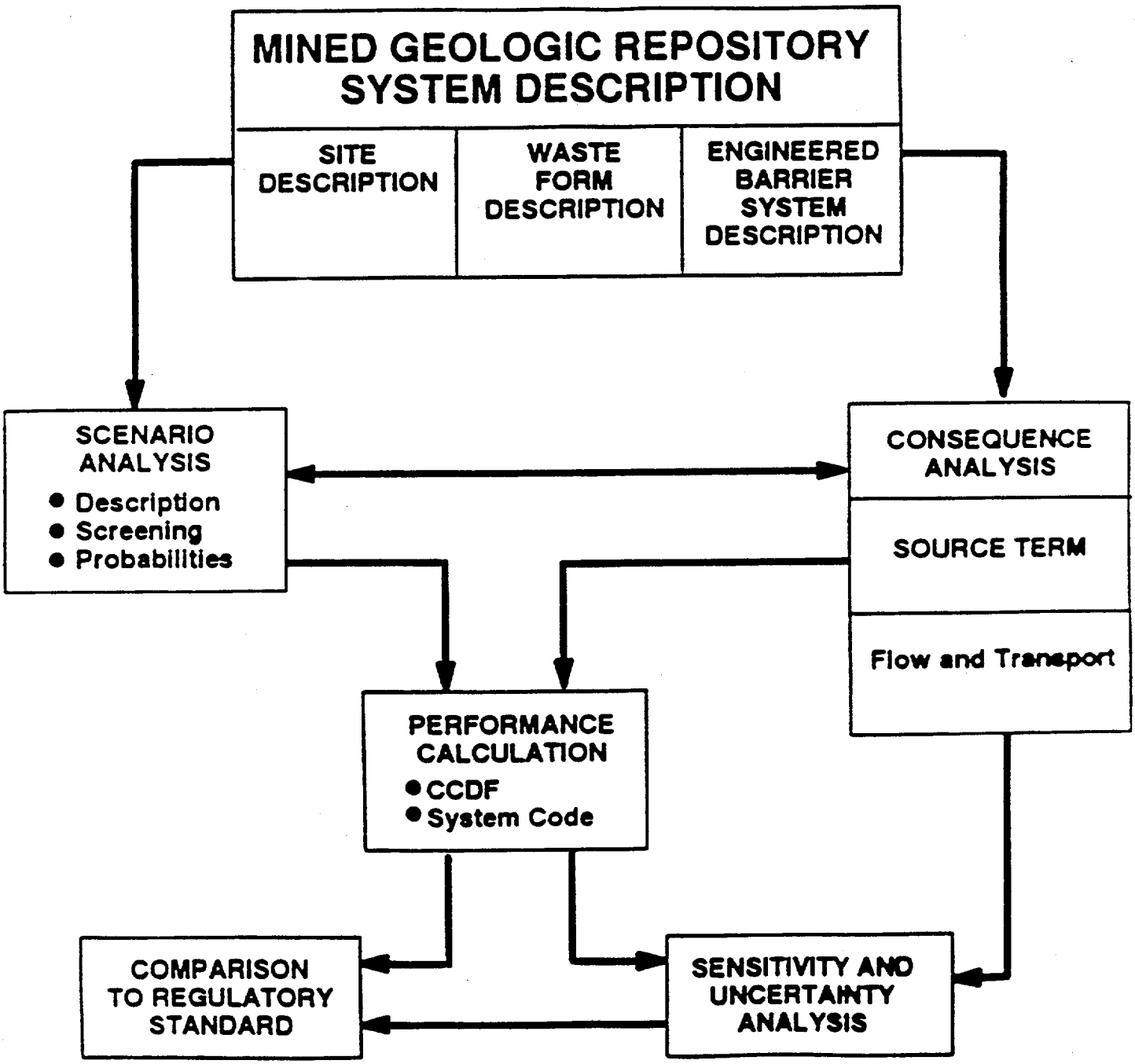
By

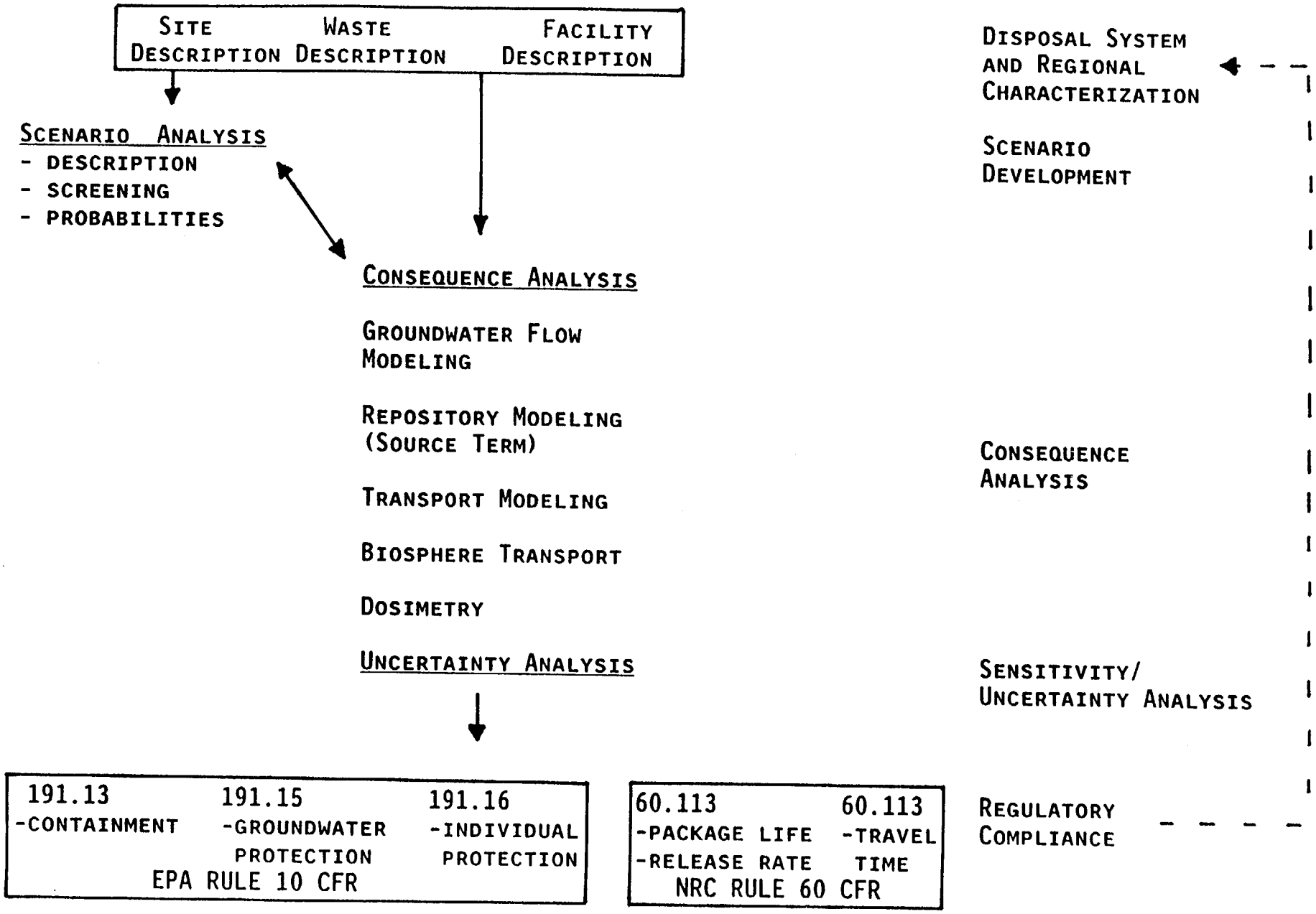
Timothy J. McCartin
Waste Management Branch
Division of Regulatory Analysis

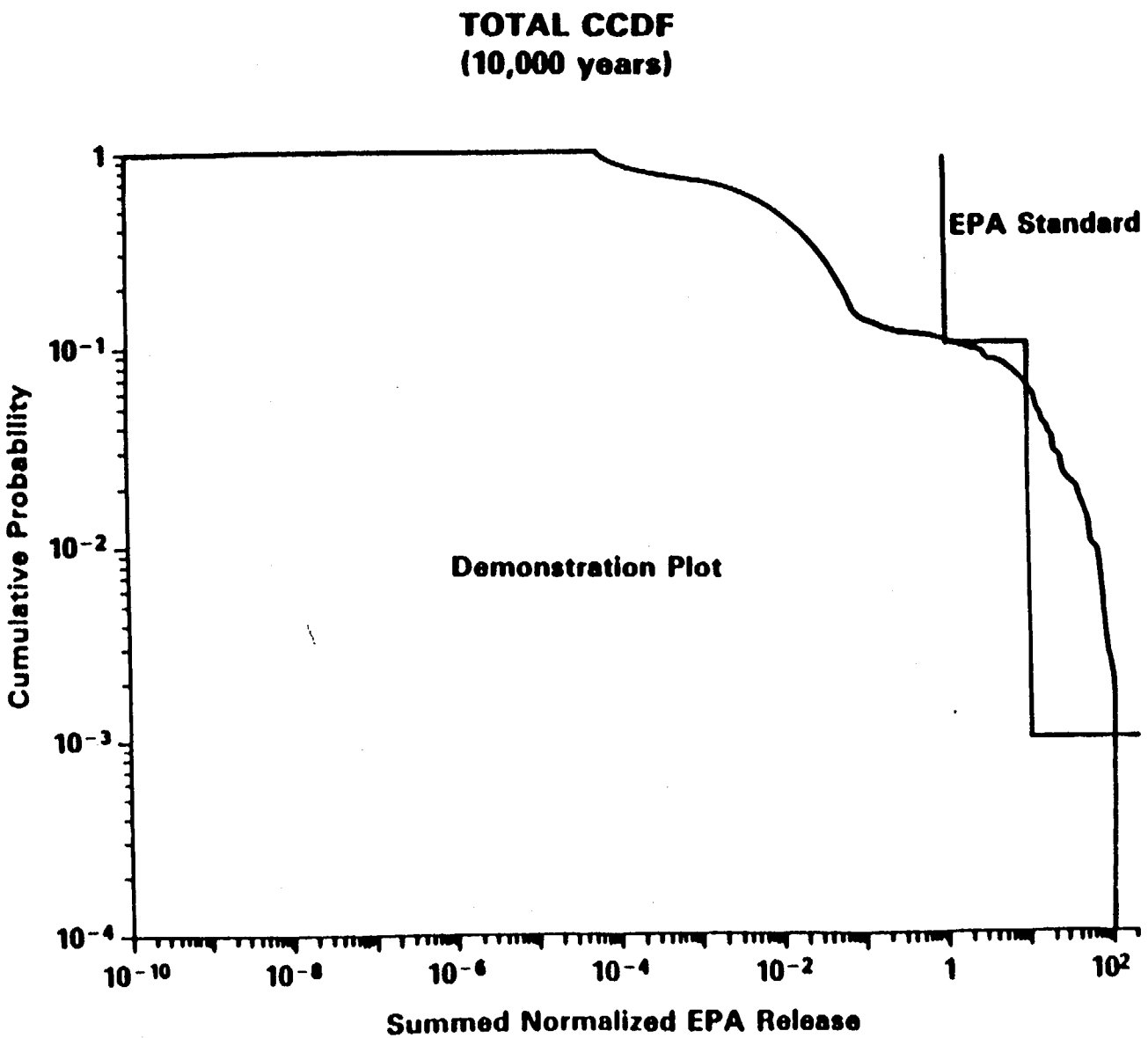
Presentation Outline

- Components of Total System PA
- Historical Perspective of PA Research Activities
- Basis for PA Research Activity
- Scenario Screening and Identification
- Contributions to Development of a Total System Code
- Model Validation: A Process

COMPONENTS OF TOTAL SYSTEM PERFORMANCE ASSESSMENT




SITE DESCRIPTION
WASTE DESCRIPTION
FACILITY DESCRIPTION
SCENARIO ANALYSIS
- DESCRIPTION
- SCREENING
- PROBABILITIES
CONSEQUENCE ANALYSIS
GROUNDWATER FLOW MODELING
REPOSITORY MODELING (SOURCE TERM)
TRANSPORT MODELING
BIOSPHERE TRANSPORT
DOSIMETRY
UNCERTAINTY ANALYSIS
191.13 -CONTAINMENT
191.15 -GROUNDWATER PROTECTION
191.16 -INDIVIDUAL PROTECTION
EPA RULE 10 CFR
60.113 -PACKAGE LIFE
60.113 -TRAVEL TIME
-RELEASE RATE
NRC RULE 60 CFR
DISPOSAL SYSTEM AND REGIONAL CHARACTERIZATION
SCENARIO DEVELOPMENT
CONSEQUENCE ANALYSIS
SENSITIVITY/ UNCERTAINTY ANALYSIS
REGULATORY COMPLIANCE


TOTAL CCDF
(10,000 years)
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Cumulative Probability
EPA Standard
Demonstration Plot
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
10^{2}
Summed Normalized EPA Release

Previous Research Topics/Issues

Bedded Salt (Mid 70's to Early 80's)

SANDIA NAT'L LAB

- PA Methodology
- Sensitivity/Uncertainty Analyses
- Scenario Selection/Identification
- Density driven flow
- Transport of chains of radionuclides
- Dose Calculation

Basalt (Early 80's to Mid 80's)

- Verification and Validation
- Expert Opinion
- Flow and Transport in Saturated, Fractured, Porous Media

Previous Research Topics/Issues (cont.)

Tuff (Mid 80's to present)

- Flow and Transport in Unsaturated, Fractured, Porous Media
- Two-Phase Flow (thermal effects)
- Verification and Validation

PA Research Time Line

1976 (Bedded Salt)	1982 (Basalt)	1987 (Tuff)	1992
Sandia			CNWRA

CONSEQUENCE MODELS	SWIFT NWFT	SWIFT II NEFTRAN	DCM3D NEFTRAN II TOUGH	BIGFLOW PORFLOW
SENSITIVITY/ UNCERTAINTY	LHS			
VALIDATION/TESTING		INTRACOIN & HYDROCOIN	INTRAVAL	

Basis for PA Research Activity

1) NMSS PA User Needs

   - An effective means to identify and screen scenarios

   - A total system code to quantitatively assess performance

   - A methodology to validate the computational models used in PA

2) IPA Activity

   - DOE Technical Exchanges

3) SRA Process (identification of key technical uncertainties

Scenario Screening and Identification

MOTIVATION

A wide range of processes, events and conditions needs to be considered in assessing a geologic repository

PROGRAMMATIC NEED

A workable performance assessment will rely on:

- conceptual model development of processes and events
- evaluation of probabilities
- screening out implausible events and processes
- grouping of processes and events into classes

CURRENT CAPABILITY/APPROACH

Use of Sandia methodology

Scenario Screening & Identification (cont.)

CNWRA PA RESEARCH

Perform a critical review of current approaches for identifying scenarios and assigning probabilities

- probabilistic techniques
- environmental modeling

CNWRA PRODUCTS

Paper on the important issues to PA (May 1993)

Paper on the adequacy of models of the disruptive scenario classes

PROGRAM INTERACTIONS

Research projects which are anticipated to impact scenario identification and probabilities:

- hydrology (step gradients and recharge)
- volcanism
- tectonics
- natural analogs

Development of a Total System Code

MOTIVATION

A quantitative assessment of repository performance will require the consideration of many inter-related processes and events

PROGRAMMATIC NEED

The independent review of repository performance will require:

- computational methodology to evaluate the total system
- understanding of the effect(s) of model simplifications
- approaches for interfacing different models
- improved computational techniques

Total System Code (cont.)

CURRENT CAPABILITY/APPROACH

Use of Sandia far-field assessment codes

- ability to examine the "most" important mechanism (fracture-matrix interaction)
- calculates releases for comparison to integrated discharge of EPA Standard
- primarily for non-disturbed conditions
- no near-field effects
- limited variation in flow field
- has potential to be very computationally intensive
- limited source term model

Use of CNWRA codes for auxiliary analyses

-PORFLOW and BIGFLOW

Total System Code (cont.)

CNWRA PA RESEARCH

1) Development of conceptual understanding

- identification of important processes for base case and disruptive scenarios (volcanism, seismicity, climatic, and human intrusion)

- assessment of simplifications and alternative conceptual models

- examination of existing computer programs for applicability

- development of matrix-fracture interaction in unsaturated regimes

- examination of processes affecting the moisture regime in the vicinity of the canister (two-phase flow)

- examination of the formation of radiocolloids

Total System Code (cont.)

2) Examination of advances in computational methods

- massively parallel super computers

- adaptive grids in PA models

- advances in matrix solution methods

3) Development of mathematical models and implementation in computer programs

Total System Code (cont.)

CNWRA PRODUCTS

(Activity #1)

Paper on issues related to conceptual model formulation, implementation, and solution (May 1993)

Paper on adequacy of models for disruptive scenarios (3rd Quarter 1993)

NUREG on formation and transport of radiocolloids (1st Quarter 1994)

Papers on selected topics (Two-phase flow, Fracture-matrix interaction, and reactive transport)

(Activity #2)

NUREG on advanced computational methods (4th Quarter 1994)

Paper on use of massively parallel computers

Total System Code (cont.)

(Activity #3)

Computer program to implement total system code

Computer programs for disruptive scenarios

PROGRAM INTERACTIONS

All research programs contribute to conceptual model development (process identification and understanding of simplifications)

Anticipated contributors:

- hydrology (regional flow and recharge)
- thermohydrology (near field environment)
- corrosion (waste package)
- rock mechanics (waste package)
- geochemistry (retardation mechanisms)
- volcanism
- tectonics
- natural analogs

Model Validation as a Process

(10 CFR 60.21 (c) (1) (ii) (F) (Content of Application)

"Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests which are representative of field conditions, monitoring data, and natural analog studies."

Model Validation: A Process (Confidence Building)

MOTIVATION

Significant reliance on mathematical models to assess the performance of a repository requires a defensible basis for the modeling theories and assumptions

PROGRAMMATIC NEEDS

Defendable basis for PA models will rely on a framework to integrate information from:

- site specific studies
- other laboratory and field evidence
- natural analogs

CURRENT CAPABILITY/APPROACH

Participation in international efforts to build confidence in hydrologic flow and transport models (INTRACOIN, HYDROCOIN, and INTRAVAL)

Model Validation (cont.)

CNWRA PA RESEARCH

Utilization of laboratory and field information from Apache Leap field site

Continued participation in INTRAVAL

Development of a methodology for validation for PA models

- identification of appropriate data sets

- demonstration of methodology

CNWRA PRODUCTS

NUREG on validation methodology and model complexity (3rd Quarter 1994)

Paper documenting INTRAVAL participation (1st Quarter 1994)

Model Validation (cont.)

PROGRAM INTERACTIONS

Every research program area is concerned with the confidence of their models and assumptions

Natural analogs offer unique insights for spatial and temporal scales

Theoretical and experimental studies at the University of Arizona

PROGRESS IN HYDROLOGY RESEARCH

PRESENTED TO THE

NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE

DECEMBER 1, 1992

THOMAS J. NICHOLSON
WASTE MANAGEMENT BRANCH
(301) 492-3856

HYDROLOGY RESEARCH PROGRAM IN HLW

Regulatory Objectives: Assessment of -

- Ground-Water Travel Times [10 CFR Part 60.113 (a)(2)]
- Favorable Conditions dealing with Unsaturated & Saturated Conditions and Processes [10 CFR Part 60.122 (b)]
- Potentially Adverse Conditions dealing with Unsaturated & Saturated Conditions & Processes [10 CFR Part 60.122 (c)]

Technical Issues:

- Understand Unsaturated Flow & Transport Processes in Fractured Rock over a Range of Spatial & Temporal Scales
- Couple Unsaturated & Saturated Flow & Transport Processes for Integration into *Performance Assessment Analyses*

HYDROLOGY RESEARCH STUDIES IN HLW

- Field Studies at the *Apache Leap Tuff Site*

  University of Arizona (UAz)/CNWRA Studies on Ground-Water Flow & Transport Processes (including Vapor Phase)

- Conceptual Model Development

  CNWRA Studies on Stochastic Analysis of Flow and Transport

  UAz Studies on Scale Effects, Effective Parameters & Fingering

- Regional Hydrogeologic Processes in the Basin & Range

  CNWRA Studies to Examine Regional Scale Hydrogeologic Processes & Alternative Conceptual Model Development & Confirmation

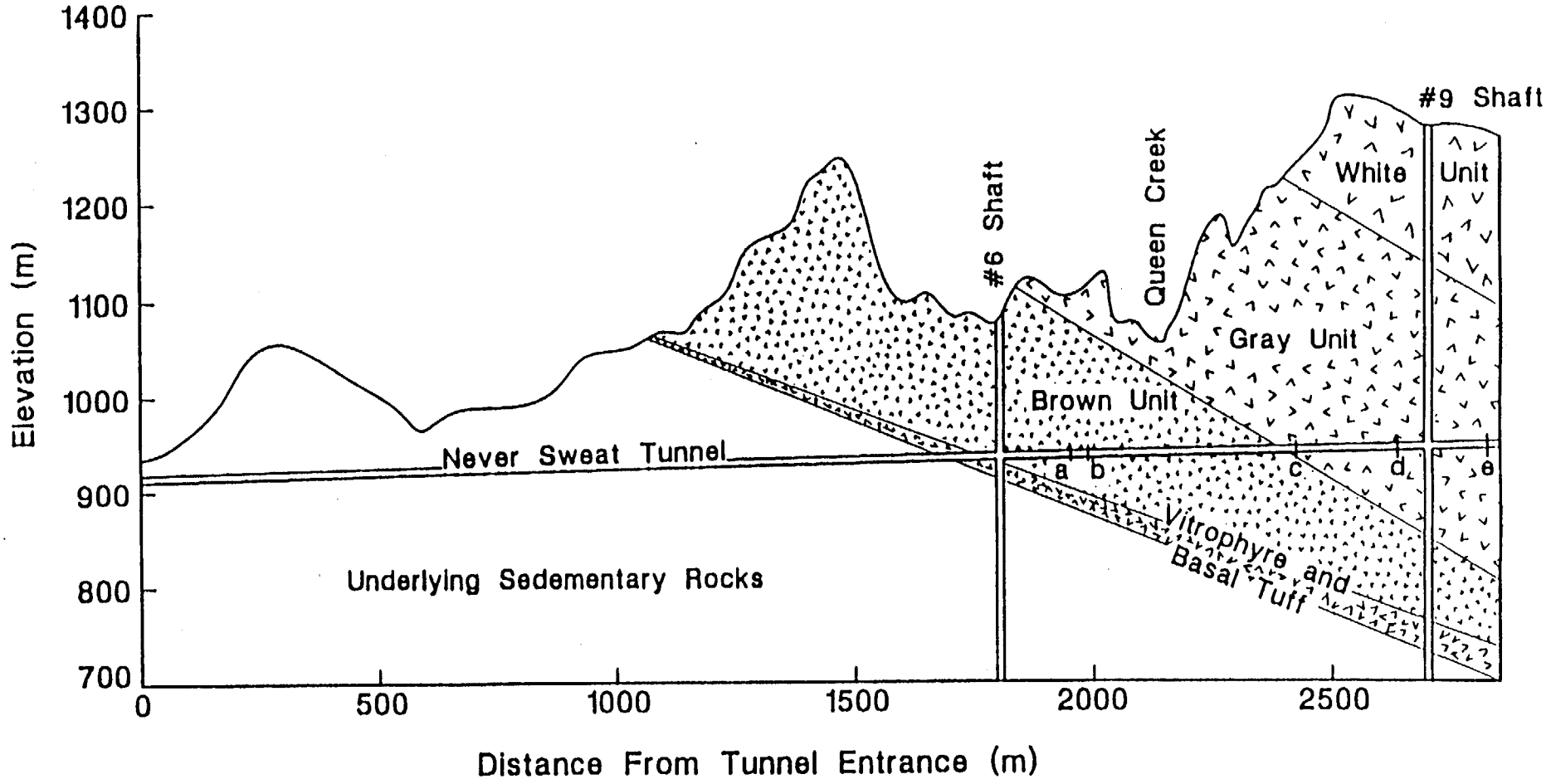
HYDROLOGY RESEARCH PROGRAM COOPERATIVE EFFORTS

- Peer Review & Cooperative Technical Interactions

  National Academy of Sciences Panel on Fracture Characterization & Fluid Flow

  INTRAVAL Project involving DOE/USGS/EPA/State of Nevada & International Parties

  Workshop VI on "Field Techniques and Instrumentation for Characterizing & Analyzing Ground-Water Flow & Transport Through Unsaturated Fractured Rock" in Tucson, AZ, January 25-28, 1993


1400
1300
1200
1100
1000
900
800
700
Elevation (m)
0
500
1000
1500
2000
2500
Distance From Tunnel Entrance (m)
#6 Shaft
Queen Creek
#9 Shaft
White
Unit
Gray Unit
Brown Unit
Never Sweat Tunnel
a
b
c
d
e
Vitrophyre and
Basal Tuff
Underlying Sedementary Rocks

FIELD STUDIES AT THE *APACHE LEAP TUFF SITE*

- Pneumatic Studies at Inclined Borehole Site to Develop Single, Cross-Hole and Interference Borehole Testing Strategies to Determine Permeability Fields in Fractured Rock

- Examination of Ground-Water Travel Times for Matrix and Fracture-Dominated Flow using Measured Fluxes &/or Potentials in Magma Mine Tunnel and Deep Inclined Borehole

- Geochemical Sampling & Analysis Using C-14 & H-3 to Confirm Flow Path & Travel Time Calculations

- Watershed Studies to Examine Infiltration/Runoff Relationships for Unsaturated Fractured Rock Settings

- Utilize Core and Water Sampling Methods & Downhole Instrumentation to Independently Confirm Site Characterization Methods

- Conduct Laboratory Analyses of Core Samples to Derive Hydraulic, Thermal & Transport Properties

CONCEPTUAL MODEL DEVELOPMENT

- CNWRA Studies to Examine Fracture Flow Modeling Approaches
  - Discrete Fracture Modeling Approach
  - Derivation of Effective Parameters for Fractured Media
  - Supercomputer Simulations of Large-Scale Unsaturated Flow & Transport with Detailed Heterogeneity Conditioned on Data
  - Spatial & Statistical Analysis of Flow Fields & Contaminant Plumes
  - 3D Visualization Graphics & Interpretation

NRC TECTONICS RESEARCH

OBJECTIVES

- THE OBJECTIVE OF THE CNWRA PROJECT IS TO TEST CONCEPTS ABOUT THE GEOLOGIC STABILITY OF THE YUCCA MOUNTAIN AREA BY EXAMINING REGIONAL TECTONIC DATA & PROCESSES

- THE OBJECTIVE OF THE CALTECH/SMITHSONIAN PROJECT IS TO TEST CONCEPTS ABOUT THE GEOLOGIC STABILITY OF THE YUCCA MOUNTAIN REGION BY MEASURING CONTEMPORANEOUS DEFORMATION RATES BY GPS & TO COMFIRM OTHER METHODS BEING USED TO MEASURE DEFORMATION IN THE REGION

NRC TECTONICS RESEARCH

CRITICAL QUESTIONS

- DOES TOTAL QUATERNARY OFFSET IN THE YUCCA MOUNTAIN REGION EQUAL THE SUM OF THE INDIVIDUAL OFFSETS ON KNOWN FAULTS? IS THERE UNEXPLAINED OFFSET?

- ARE MODERN GPS MEASURED STRAIN RATES CONSISTENT WITH DOE DATA, MODELS AND CONCEPTS OF YUCCA MT. STABILITY?

- ARE GPS STRAIN RATES CONSISTENT WITH QUATERNARY STRAIN RATES DETERMINED BY REGIONAL GEOLOGIC FIELD STUDIES?

NRC TECTONICS RESEARCH

PROGRESS

- INITIATED GPS RESEARCH WITH CAL TECH/SMITHSONIAN
  - B. WERNICKE & J. DAVIS, Principal Investigators
  - BENCHMARKS EMPLACED & FIRST SURVEY COMPLETED

- STATEMENT OF WORK SENT TO CNWRA FOR TECTONICS PROJECT
  - PROJECT PLAN FROM CNWRA WILL BE RECEIVED THIS MONTH
  - GEOLOGY LITERATURE REVIEW COMPLETED
    (shared task with volcanism project)

NRC TECTONICS RESEARCH

FUTURE DIRECTION

- CNWRA TECTONICS PROJECT IS FIELD ORIENTED
  - FIELD STUDY AWAITS HIRING OF SPECIALIST
  - CONFIRMATORY GEOLOGIC RESEARCH WILL EXAMINE APPARENT OFFSETS OF LARGE/REGIONAL GEOLOGIC STRUCTURES TO COMPARE WITH SMALLER SCALE INVESTIGATIONS OF INDIVIDUAL FAULTS & STRUCTURES

- CNWRA STUDY RESULTS WILL BE COMPARED WITH GPS DATA TO DEVELOP A BETTER UNDERSTANDING OF THE TECTONIC PROCESSES AFFECTING YUCCA MOUNTAIN

PROGRESS IN GEOCHEMISTRY RESEARCH

PRESENTED TO THE
NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE
1 DECEMBER 1992

PRESENTED BY
GEORGE F. BIRCHARD
USNRC OFFICE OF RESEARCH
tel. (301)492-3864

GEOCHEMISTRY RESEARCH

OBJECTIVES

ASSESS KEY GEOCHEMISTRY UNCERTAINTIES AFFECTING:

- CONTROLLED RELEASE
  - RADIONUCLIDE SOURCE TERM
- CONTAINMENT
  - WASTE PACKAGE ENVIRONMENT
- GROUNDWATER TRAVEL TIME
  - GROUNDWATER DATING METHODS
- RADIONUCLIDE RELEASE TO THE ACCESSIBLE ENVIRONMENT
  - RADIONUCLICE TRANSPORT IN GROUNDWATER
  - C-14 TRANSPORT IN GAS PHASE
- 10CFR60.122 FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS

GROUNDWATER, GAS, AND MINERAL CHEMISTRY AFFECT

CONTAINMENT

- Waste package degradation processes

SOURCE TERM

- Waste form alteration and dissolution
- Radioelement solubilities

TRANSPORT

- Hydrologic and transport properties:
  Porosity, permeability, saturation, tortuosity
- Radioelement speciation
- Distribution of radioelements among phases and on surfaces (retardation)

Excerpts from Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada. Yucca Mountain Site Characterization Project. SAIC-91/8000. January, 1992.

Page 2-37:

"Clinoptilolite-rich formations at Yucca Mountain are expected to play an important role in retarding radionuclides that may be released from the potential repository, and a considerable amount of chemical modeling has been done to investigate the sorptive potential of clinoptilolite (Bruton and Viani, 1990)."

Page 2-39:

"Localized repository-induced alteration of the lower vitrophyre in the Topopah Spring Member is probable (Levy and O'Neil, 1989). The mineralogic data suggest that the vitrophyre, thus altered, may have equal or increased capability to retard radionuclide transport."

GEOCHEMISTRY RESEARCH PROJECT

OBJECTIVES:

- UNDERSTAND AMBIENT GEOCHEMICAL CONDITIONS AND POTENTIAL CHANGES IN GEOCHEMICAL CONDITIONS AND PROCESSES AT THE PROPOSED HLW REPOSITORY
  - NEAR-FIELD GEOCHEMISTRY
  - FAR-FIELD GEOCHEMISTRY
- EVALUATE ISSUES AND UNCERTAINTIES IN PREDICTIVE GEOCHEMICAL MODELS USED IN PERFORMANCE ASSESSMENT

TECHNICAL APPROACH:

TASK 2 - GEOCHEMICAL MODELING OF ROCK-WATER-GAS INTERACTIONS

TASK 3 - EXPERIMENTAL STUDIES OF MINERAL-SOLUTION REACTION KINETICS AND EQUILIBRIA

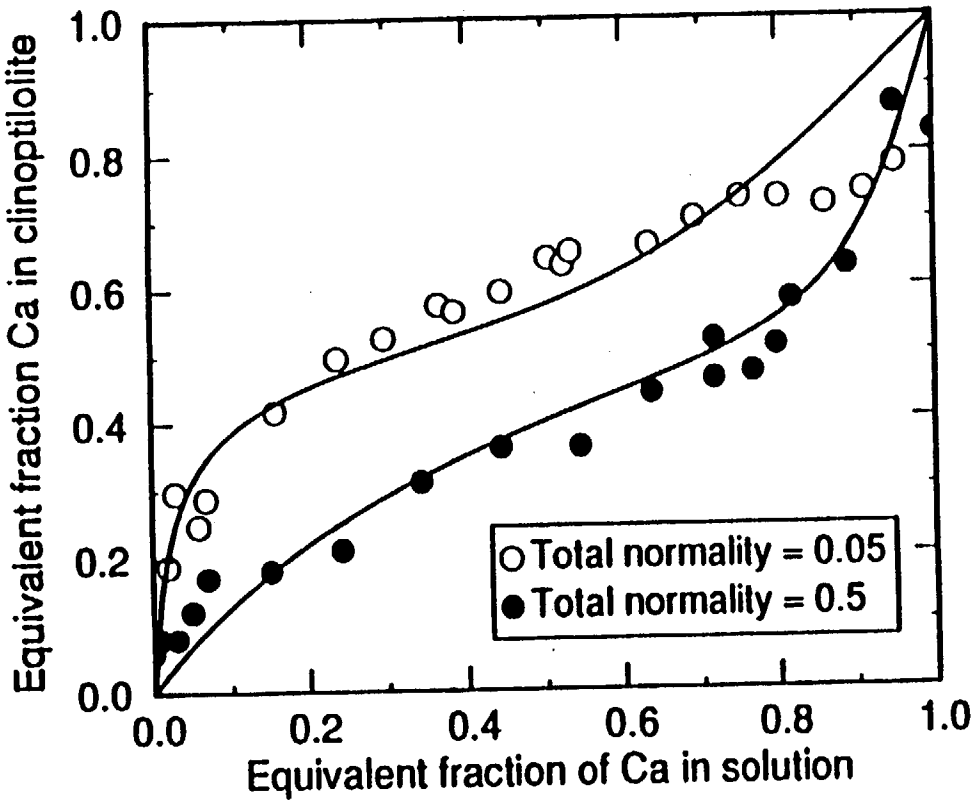
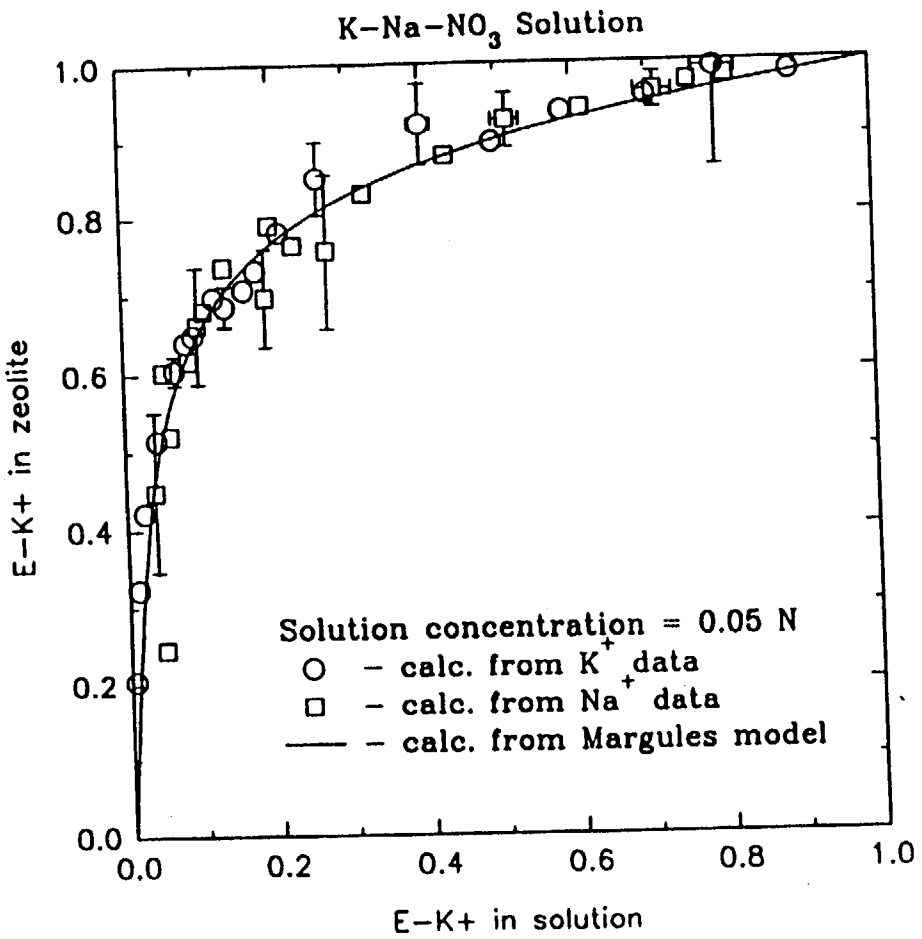


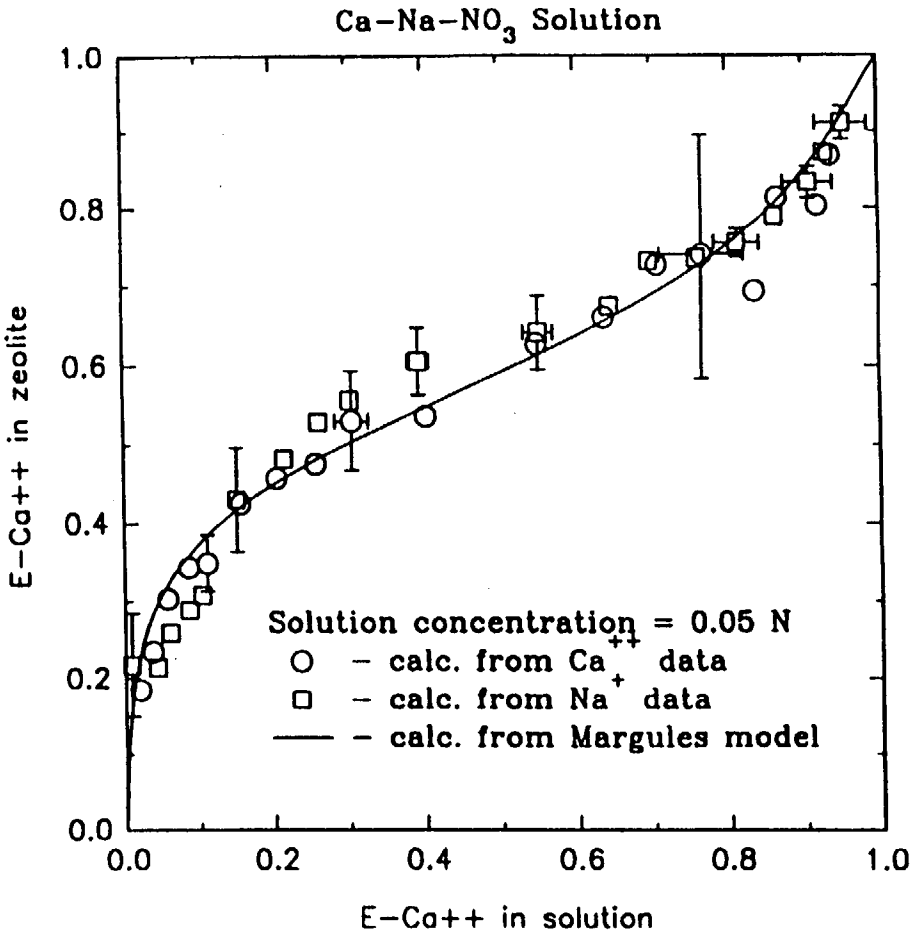
Fig. 4. Na–Ca isotherm. Data (symbols) from Pabalan 1991; two-site Vanselow model (lines) calculated with parameters in Table 1.

Water Rock Interaction, Kharaka & Maest (eds) © 1992 Balkema, Rotterdam ISBN 90 5410 075 3

Modeling ion exchange in clinoptilolite using the EQ3/6 geochemical modeling code

B.E. Viani & C.J. Bruton
Lawrence Livermore National Laboratory, Calif., USA


K–Na–NO3 Solution
E–K+ in zeolite
E–K+ in solution
0.0
0.2
0.4
0.6
0.8
1.0
Solution concentration = 0.05 N
○ – calc. from K+ data
□ – calc. from Na+ data
—— – calc. from Margules model


Ca–Na–NO3 Solution
E–Ca++ in zeolite
E–Ca++ in solution
0.0
0.2
0.4
0.6
0.8
1.0
Solution concentration = 0.05 N
○ – calc. from Ca++ data
□ – calc. from Na+ data
—— – calc. from Margules model

ION EXCHANGE STUDIES

CONCLUSIONS:

- ION EXCHANGE BETWEEN AQUEOUS SOLUTIONS AND CLINOPTILOLITE IS KINETICALLY FAST
- ION EXCHANGE IS REVERSIBLE
- THERMODYNAMIC MODELS ALLOW PREDICTION OF ION EXCHANGE ISOTHERMS AS A FUNCTION OF AQUEOUS COMPOSITION AND CONCENTRATION

SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

REGULATORY BASIS:

10CFR60.122(b) FAVORABLE CONDITIONS

(3)(i) GEOCHEMICAL CONDITIONS THAT PROMOTE PRECIPITATION OR SORPTION OF RADIONUCLIDES

10CFR60.122(c) POTENTIALLY ADVERSE CONDITIONS

(8) GEOCHEMICAL PROCESSES THAT WOULD REDUCE SORPTION OF RADIONUCLIDES

SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

OBJECTIVES:

- OBTAIN A MECHANISTIC UNDERSTANDING OF SORPTION PROCESSES IMPORTANT IN YUCCA MOUNTAIN GEOLOGIC ENVIRONMENT
- INVESTIGATE APPLICABILITY OF COUPLED HYDROGEOCHEMICAL MODELS WHICH USE SIMPLE REPRESENTATIONS OF SORPTION PHENOMENA
- DEVELOP PRACTICAL BUT SCIENTIFICALLY DEFENSIBLE APPROACHES TO MODELING SORPTION AND REQUISITE DATABASES

SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

TASK 1 - LITERATURE REVIEW (COMPLETED 2ND QUARTER, FY92)

- MAJOR MILESTONE REPORTS:
  - 'SORPTION MODELING FOR HLW PERFORMANCE ASSESSMENT: A LITERATURE REVIEW'
  - 'EFFECTS OF VARIABLE HYDROLOGIC SATURATION ON SORPTION MODELING FOR HIGH-LEVEL WASTE PERFORMANCE ASSESSMENT: A LITERATURE REVIEW'

- WORKPLANS SUBMITTED AND APPROVED:
  - 'HYDROGEOCHEMICAL MODELING OF RADIONUCLIDE TRANSPORT'
  - 'EXPERIMENTAL STUDIES ON URANIUM SORPTION ON GEOLOGIC MEDIA'

SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

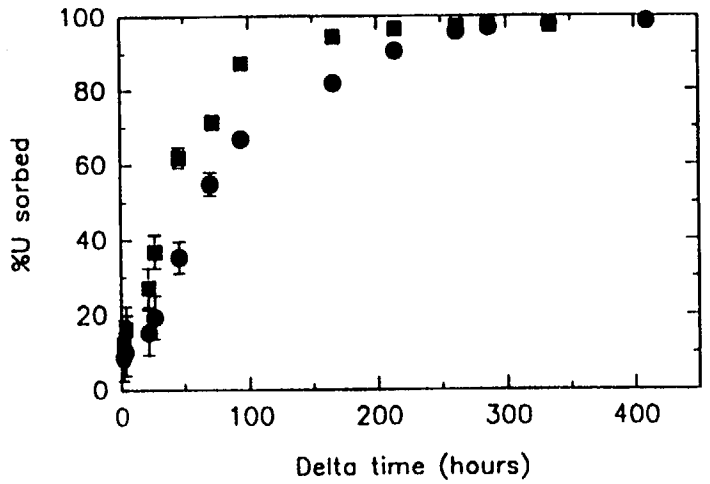
TASK 3 - SORPTION EXPERIMENTS

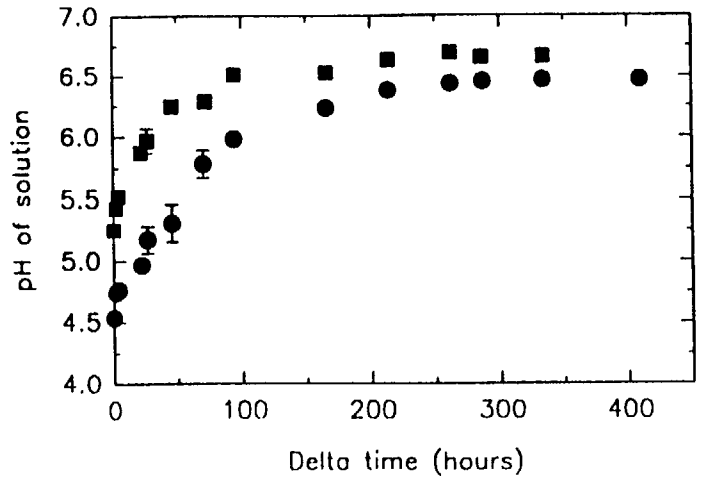
OBJECTIVES:

- DERIVE EXPERIMENTAL DATA ON SORPTION OF URANIUM AND OTHER RADIONUCLIDES
- EVALUATE EFFECTS OF SOLUTION CHEMISTRY AND ROCK/MINERAL PROPERTIES ON RADIONUCLIDE SORPTION
- IDENTIFY SORPTION PROCESSES/MECHANISMS IMPORTANT TO YUCCA MOUNTAIN ENVIRONMENT

SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

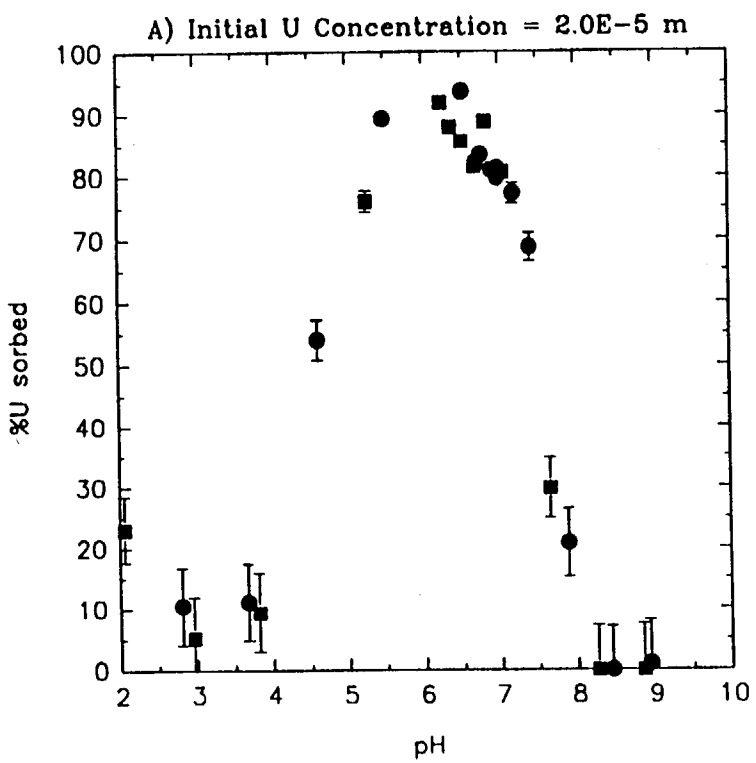
KINETICS OF URANIUM SORPTION ON CLINOPTILOLITE:

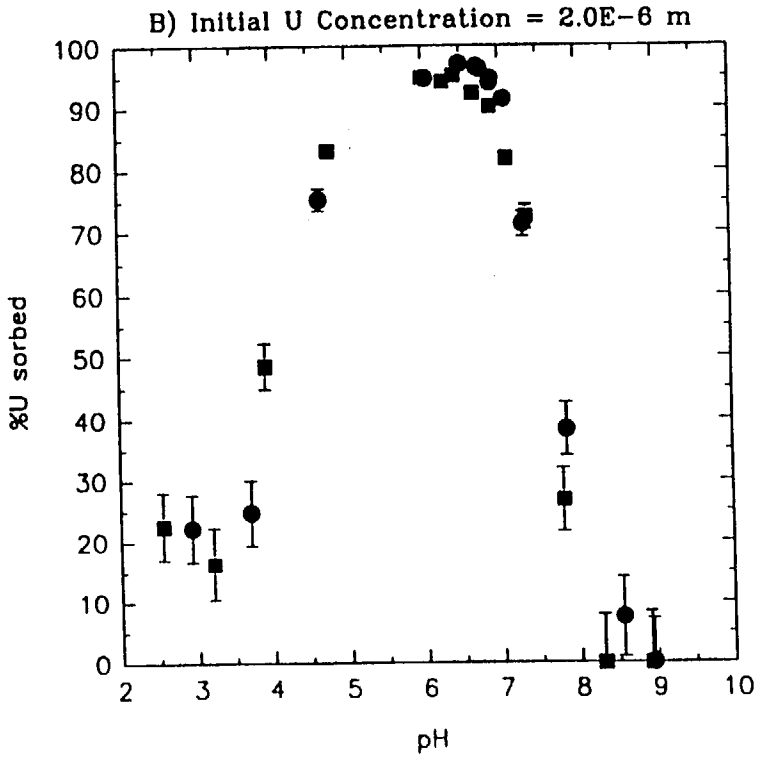




SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

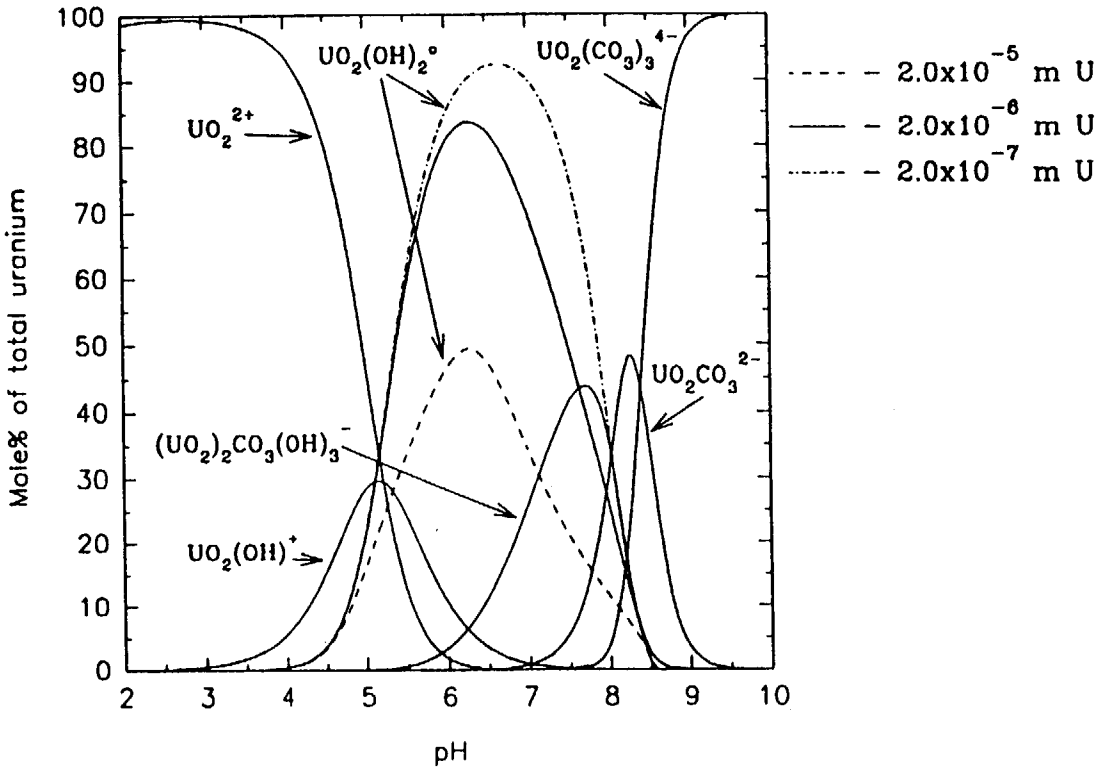
URANIUM SORPTION ON CLINOPTILOLITE VERSUS EQUILIBRIUM pH:





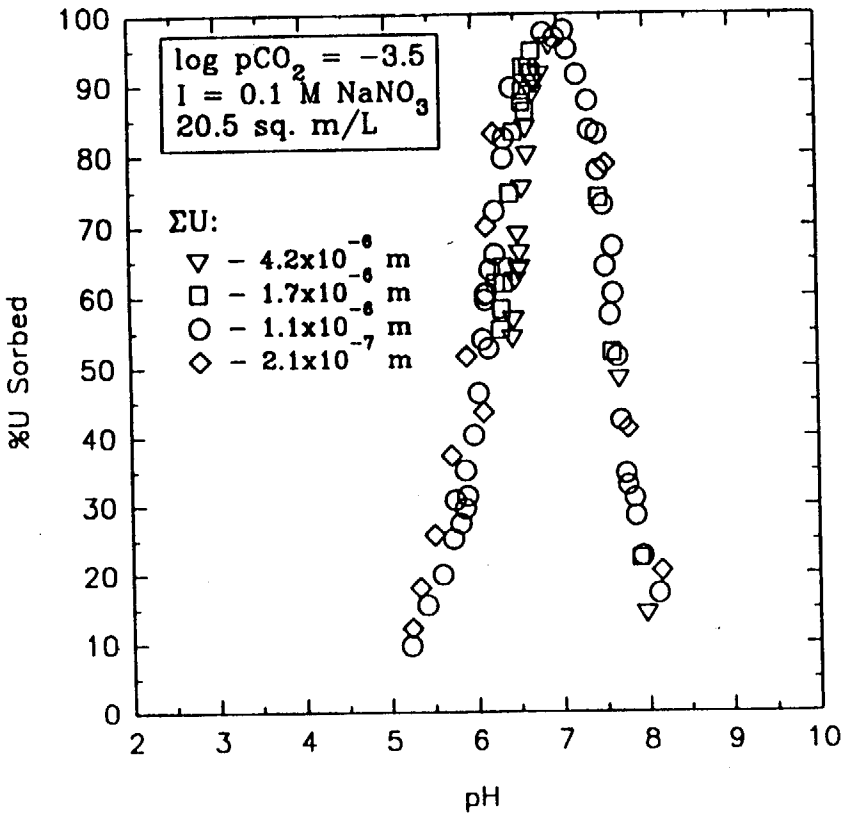
SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

AQUEOUS URANIUM(6+) SPECIATION VERSUS pH:

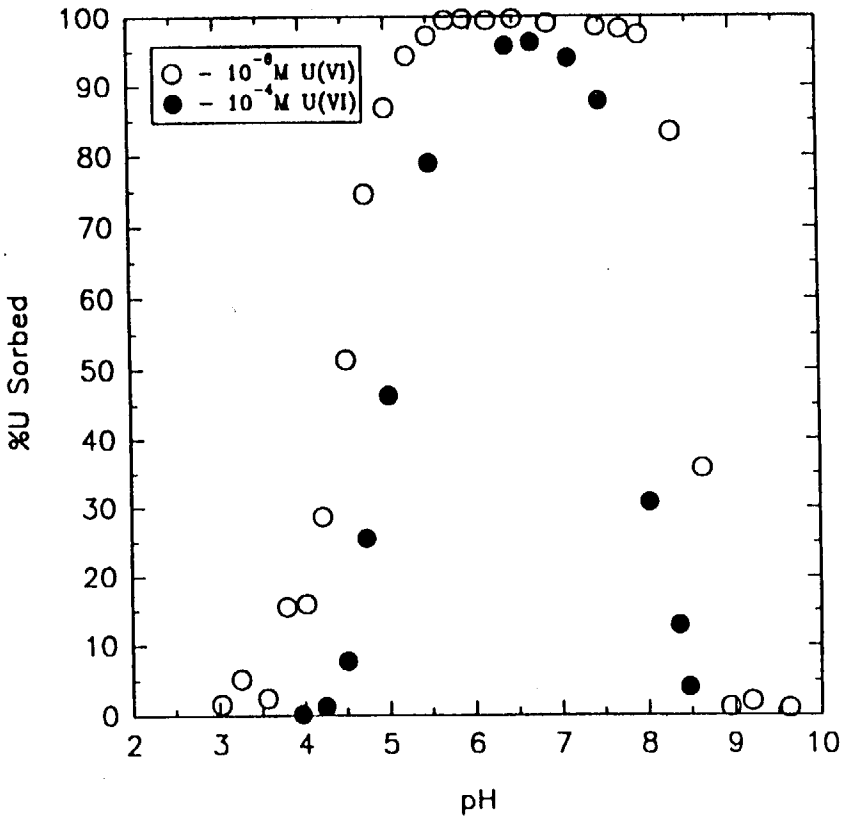


SORPTION MODELING FOR HIGH LEVEL WASTE PERFORMANCE ASSESSMENT

URANIUM SORPTION ON GOETHITE VERSUS EQUILIBRIUM pH (data from Tripathi, 1984):



URANIUM SORPTION ON FERRIHYDRITE VERSUS EQUILIBRIUM pH (data from Payne et al., 1992):



GEOCHEMISTRY RESEARCH

MAJOR ACCOMPLISHMENTS

- GEOCHEMISTRY PROJECT
  - -PUBLISH FINAL RESULTS OF ANALCIME DISSOLUTION STUDY
  - -PUBLISH FINAL RESULTS OF ION EXCHANGE EXPERIMENTS ON CLINOPTILOLITE

- SORPTION PROJECT
  - -COMPLETE LITERATURE REVIEW
  - -INITIATE EXPERIMENTS ON URANIUM SORPTION ON ZEOLITE
  - -INITIATE SORPTION MODELLING STUDIES

- COMPLETE ALLIGATOR RIVERS ANALOGUE PROJECT
  - -FINAL PRESENTATIONS GIVEN AT NATURAL ANALOGUES MEETING
  - -FINAL REPORTS GOING TO PRESS - 17 VOLUMES
  - -ARAP WILL BE DISCUSSED AFTER FINAL REPORTS RECEIVED

CNWRA
Thermohydrologics Research Project

NRC Project Officer: John D. Randall
Waste Management Branch
Division of Regulatory Applications
Office of Nuclear Regulatory Research
(301) 492-3873

CNWRA Investigators: Randall Manteufel, Ronald Green, Franklin Dodge, Steven Svedeman

Project Objective:

To understand how the heat generated by emplaced HLW redistributes liquid groundwater in a repository in unsaturated fractured rock.

Application of Results:

- Provide estimates of temperature and degree of groundwater saturation near emplaced HLW - sets environment for corrosion (10 CFR 60.113), radionuclide release (60.113), and local chemical effects on radionuclide transport near the waste (60.112).

- Provide means of estimating the boundary of the thermally disturbed zone around the waste, for use in estimating groundwater travel time. (60.113)

- Provide estimates of thermal loading for use in estimating coupled thermal, hydrological, mechanical, and chemical effects on waste containment, waste release, groundwater flow, and waste transport.

Research Approach:

- Do laboratory-scale experiments.
- Simulate the experiments with mathematical models to test the models' validity for performance assessment.
- Extend the experimental results to repository scales via similitude.

Repository Scales Represented:

- Whole repository, examining thermohydrological phenomena far from the emplaced HLW.
- A few waste packages, examining thermohydrological phenomena near the emplaced HLW, investigating possibility of heat piping.

Progress:

- Scoping of problem: Theoretical and conceptual considerations for two-phase flow in unsaturated fractured porous media.
- Derivation of conservation and constitutive equations.
- Similitude analysis.
- Evaluation of instrumentation.
- Separate effects experiments.
- Mathematical simulation of separate effects experiments.

Peer Review, May 1992:

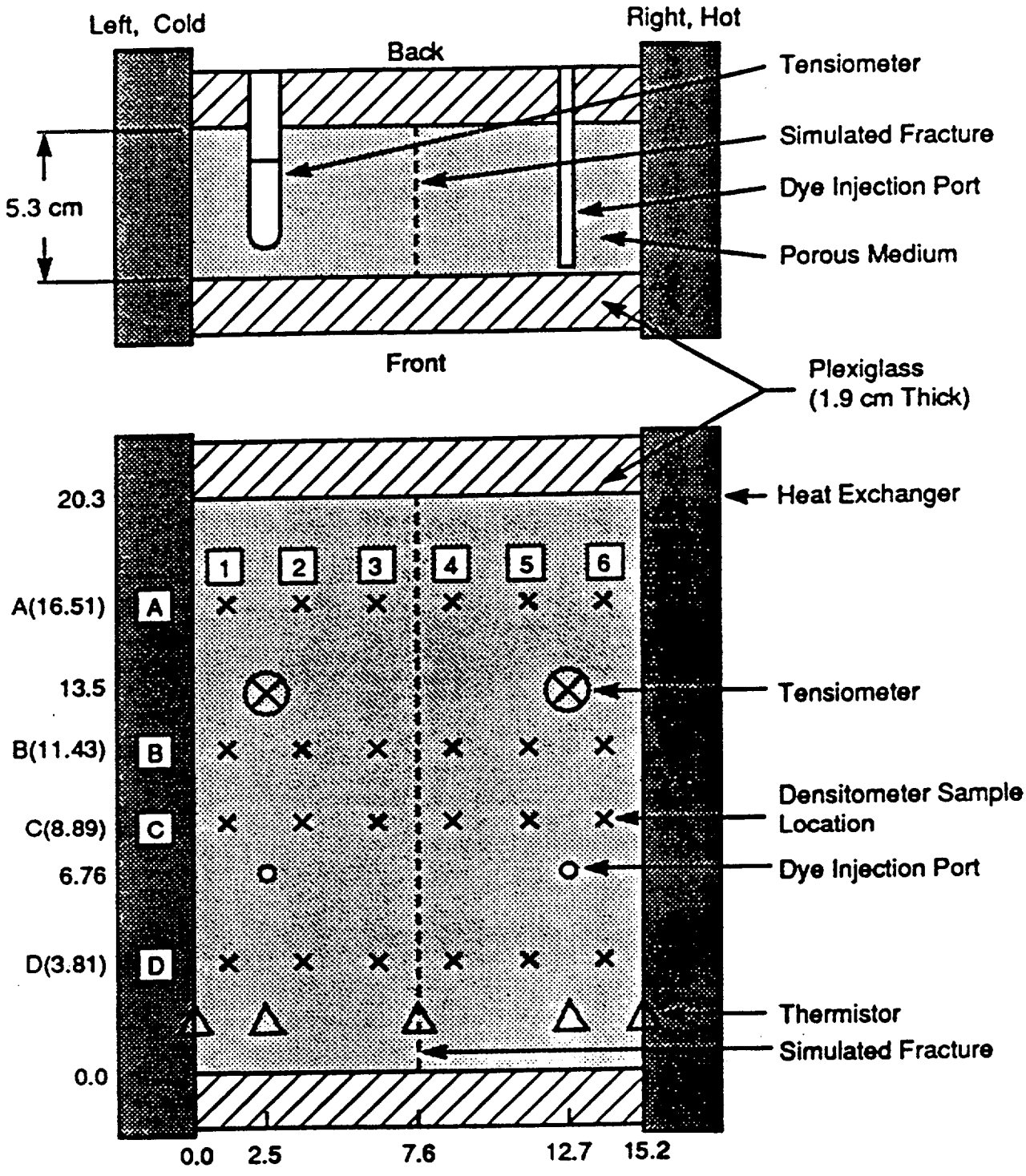
Reviewer	Affiliation	Expertise
Daniel Evans	Hydrology and Water Resources, University of Arizona	Unsaturated zone field hydrogeology
Massoud Kaviany	Mechanical and Aerospace Engineering, University of Michigan	Heat transfer in porous media
Owen Phillips	Earth and Planetary Sciences, Johns Hopkins University	Flow and reactions in permeable rocks
Vijay Dhir	Mechanical, Aerospace, and Nuclear Engineering, UCLA	Heat and mass transfer associated with phase change
Frederick Moody	General Electric, San Jose State University	Thermal hydraulics, especially in reactors

Separate Effects:

- Liquid infiltration and distribution.
- Local heating of pore liquid.
- Gas and liquid convection without phase change.
- Transient heating.
- Matrix-fracture interaction.

Observations:

- Measured temperature (thermistors), suction pressure (tensiometers), and moisture content (gamma-ray densitometers).
- Used dye to observe liquid water movement.

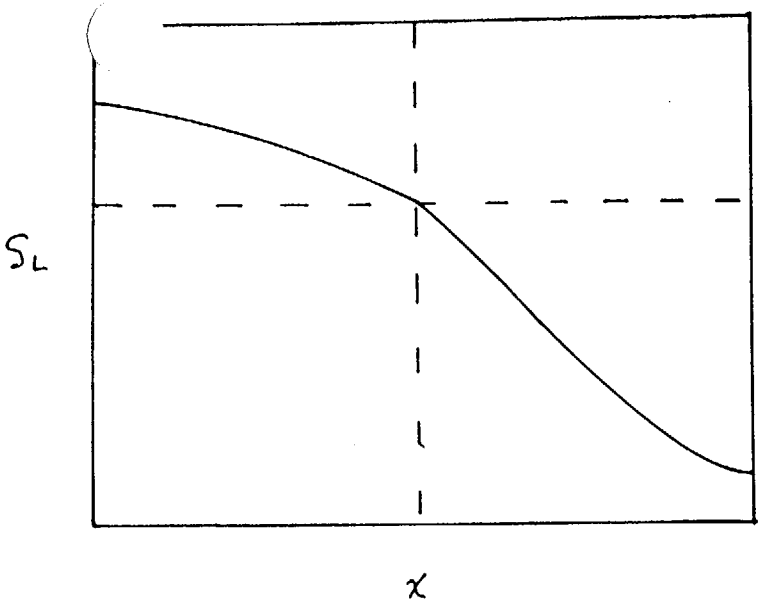

Left, Cold
Back
Right, Hot
Tensiometer
Simulated Fracture
Dye Injection Port
Porous Medium
5.3 cm
Front
Plexiglass
(1.9 cm Thick)
Heat Exchanger
20.3
1
2
3
4
5
6
A(16.51)
A
13.5
Tensiometer
B(11.43)
B
Densitometer Sample
Location
C(8.89)
C
6.76
Dye Injection Port
D(3.81)
D
Thermistor
Simulated Fracture
0.0
0.0
2.5
7.6
12.7
15.2

Mathematical Simulations:

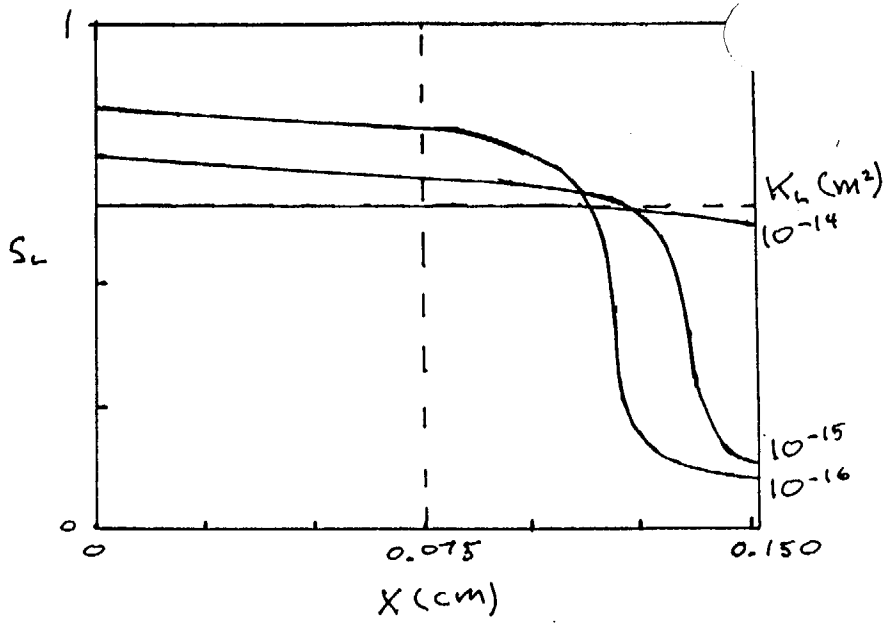
- Used TOUGH to simulate redistribution of liquid and vapor in the presence of a fracture (matrix-fracture interaction). TOUGH will be used in auxiliary analyses in NRC's Iterative Performance Assessments.

- Simulations predicted fracture acting as a barrier to liquid water movement, observed experimentally.

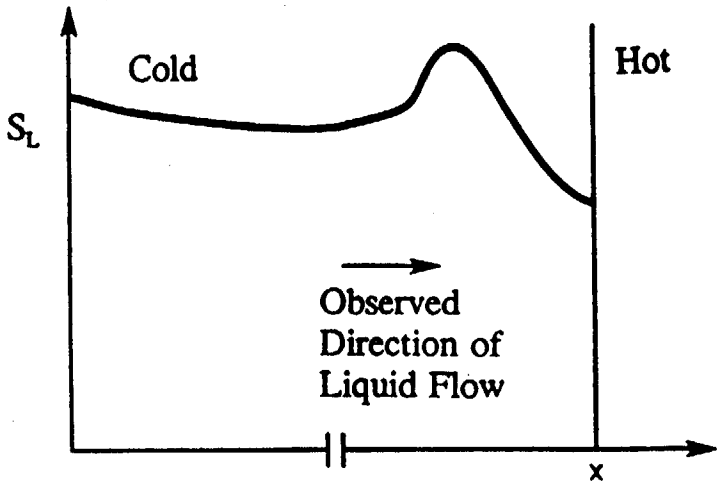
- Simulations failed to predict observed drying fronts and wet bands caused by liquid water moving in the direction of increasing saturation and increasing temperature. Weakness appears to be failure of mathematical model to account for hysteresis in dependence of capillary adsorption pressure on liquid saturation. TOUGH may be underestimating amount of liquid water available for corrosion, release, and transport.

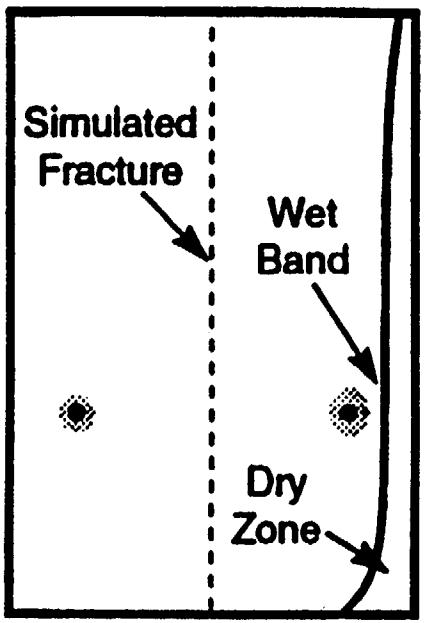


Conceptual Model

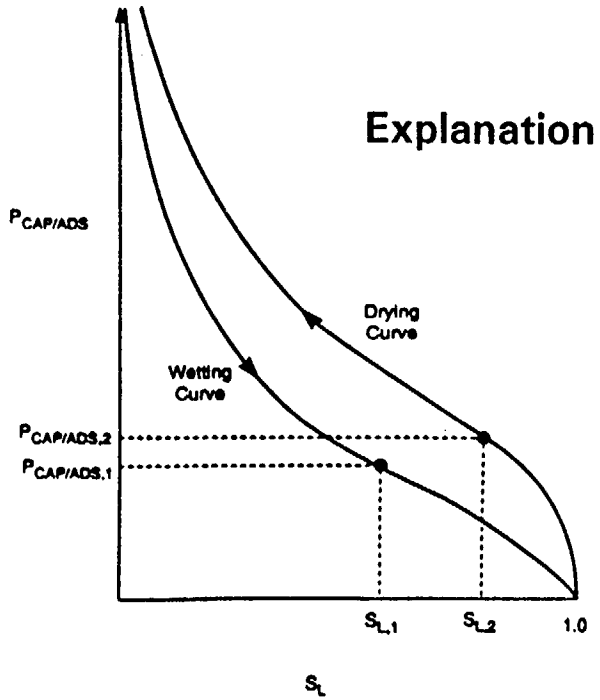


Mathematical Model





Physical Model



Similitude Considerations:

- Twenty three similitude parameters (not including non-dimensional independent and dependent variables) were identified. Order-of-magnitude arguments reduced the set to ten.

- Experiments showed varying degrees of sensitivity of observed temperatures, pressures, and flow fields to several similitude parameters, e.g. little sensitivity to capillarity number (liquid viscous force/surface tension force) and gaseous Prandtl number (viscous diffusion/thermal diffusion), moderate sensitivity to gaseous Lewis number (molecular diffusion/thermal diffusion), and high sensitivity to surface tension ratio (change of surface tension with temperature).

Future plans:

- The saturation curves used in TOUGH will be modified to account for hysteresis and simulations of the matrix-fracture tests will be repeated.

- Multiple-thermohydrological-effects experiments are being designed, emphasizing simulations of the repository and waste package scales.

- The examination of the importance of individual similitude parameters will continue.

- Yucca Mountain data will be examined for estimations of dimensionless similitude parameters.

- The project is scheduled for completion at the end of FY 94.

SEISMIC RESPONSE OF UNDERGROUND OPENINGS

PRESENTED BY

JACOB PHILIP
GEOTECHNICAL ENGINEER
WASTE MANAGEMENT BRANCH
OFFICE OF NUCLEAR REGULATORY RESEARCH

To

THE NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE
NUCLEAR WASTE SUBCOMMITTEE

DECEMBER 1, 1992

SEISMIC ROCK/MECHANICS RESEARCH PROJECT

OBJECTIVES:

- TO OBTAIN AN UNDERSTANDING OF THE IMPORTANT PARAMETERS ASSOCIATED WITH THE RESPONSE OF FRACTURED TUFF ROCK SUBJECTED TO REPETITIVE SEISMIC MOTIONS.

- TO STUDY THE EFFECTS OF SEISMIC MOTION ON GEOHYDROLOGY AND ITS SIGNIFICANCE ON THE LONG TERM PERFORMANCE OF UNDERGROUND REPOSITORY STRUCTURES.

- TO EVALUATE, VALIDATE, AND REDUCE UNCERTAINTIES IN THE PREDICTIVE MODELS USED IN THE SEISMIC ASSESSMENT OF FRACTURED ROCK MEDIUM.

REGULATORY BASIS

PRECLOSURE PERFORMANCE OBJECTIVES

- Releases of radioactive materials
- Retrievability

PRECLOSURE DESIGN CRITERIA

- Protection against natural phenomena

POSTCLOSURE PERFORMANCE OBJECTIVES

- Waste packages
- Radionuclide releases

INTEGRATED PERFORMANCE ASSESSMENTS

SEISMIC ROCK MECHANICS RESEARCH PROJECT

TECHNICAL APPROACH

- o DEVELOP AN UNDERSTANDING OF THE INFORMATION CURRENTLY AVAILABLE FOR SEISMIC EFFECTS ON UNDERGROUND STRUCTURES

- o ASSESS THE CAPABILITIES AND LIMITATIONS OF ROCK-JOINT MODELS AND COMPUTER CODES CURRENTLY IN USE BY:

    - CONCEPTUAL MODELS
    - EXPERIMENTAL STUDIES

- o COMPARE PREDICTIONS OF THE ROCK-MODELS AND COMPUTER CODES USED FOR SEISMIC ANALYSIS IN JOINTED ROCK AGAINST:

    - LABORATORY MODELS STUDIES
    - INSTRUMENTED FIELD STUDIES
    - NTS WEAPONS EFFECT DATA

SEISMIC ROCK MECHANICS RESEARCH PROJECT

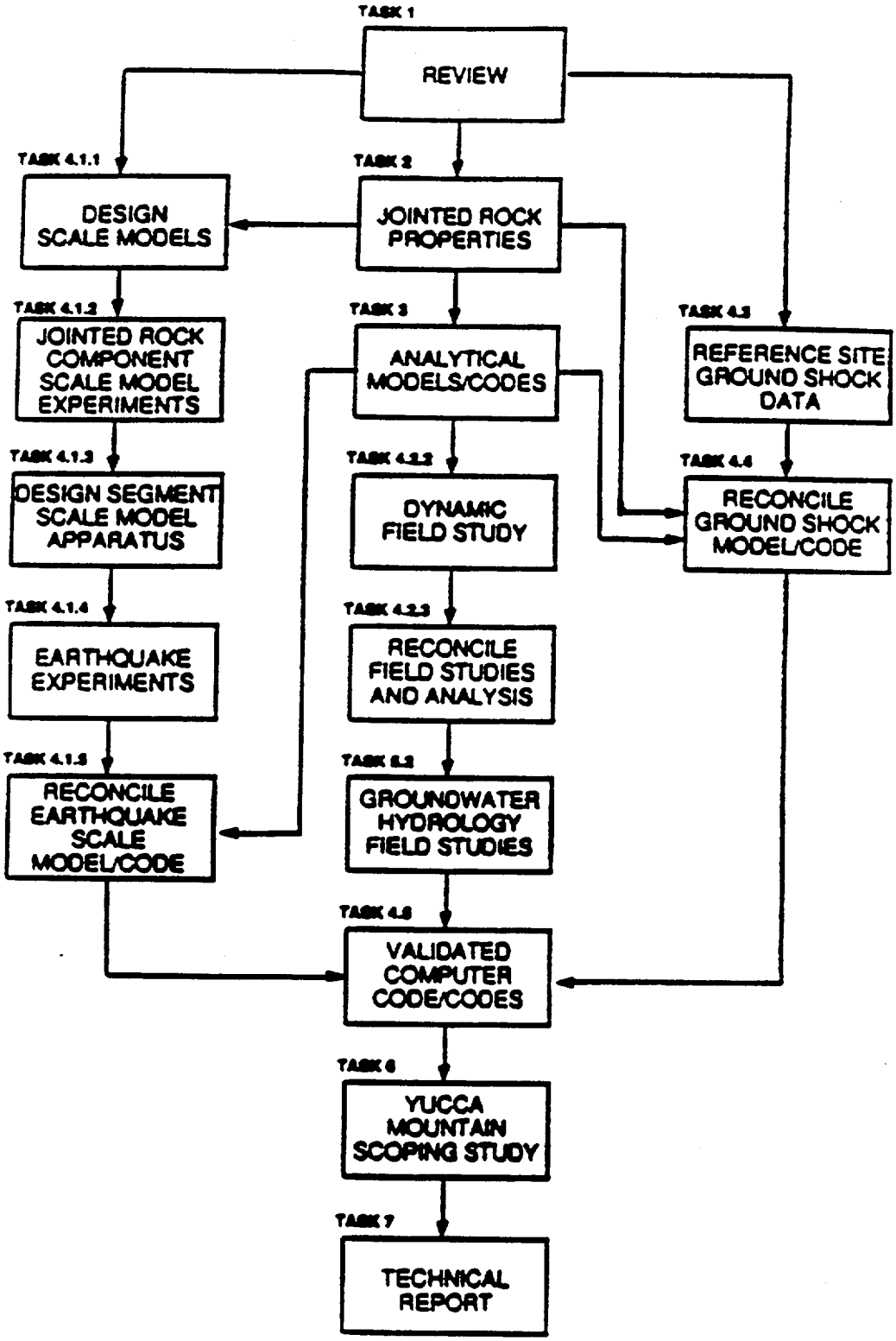
TECHNICAL APPROACH (CONTINUED):

- ASSESS BY INSTRUMENTED FIELD STUDIES THE SIGNIFICANCE OF SEISMIC EFFECT ON GEOHYDROLOGY AND DEMONSTRATE THE DEGREE OF VALIDATION FOR THE ROCK-JOINT MODELS AND COMPUTER CODES FOR SIMULATION OF SEISMIC EFFECTS ON GROUNDWATER HYDROLOGY.

- IDENTIFY AND ASSESS THE KEY SEISMIC-RELATED PARAMETERS THAT ARE APPLICABLE TO THE YUCCA MOUNTAIN SITE (DEFERRED).

- GENERATE TECHNICAL DATA FOR PREPARING REGULATORY GUIDANCE AS THEY RELATE TO THE EFFECT OF SEISMIC MOTION ON THE UNDERGROUND REPOSITORY.

LOGIC AND INTEGRATION OF PROJECT TASKS



SEISMIC/ROCK MECHANICS PROJECT

PRESENTATIONS/PUBLICATIONS

- GEOTECHNICAL BOARD, NATIONAL ACADEMY OF SCIENCES
- U.S. NATIONAL COMMITTEE ON ROCK MECHANICS, GEOTECHNICAL BOARD, NATIONAL ACADEMY OF SCIENCES
- U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD
- DECOVALEX MEMBER COUNTRIES GROUP
- ASCE HLW DYNAMIC DESIGN COMMITTEE
- OVER 16 PAPERS IN PROCEEDINGS OF WORKSHOPS, INTERNATIONAL HLW CONFERENCES, PEER REVIEWED JOURNALS

SEISMIC FIELD STUDIES

AT

LUCKY FRIDAY MINE

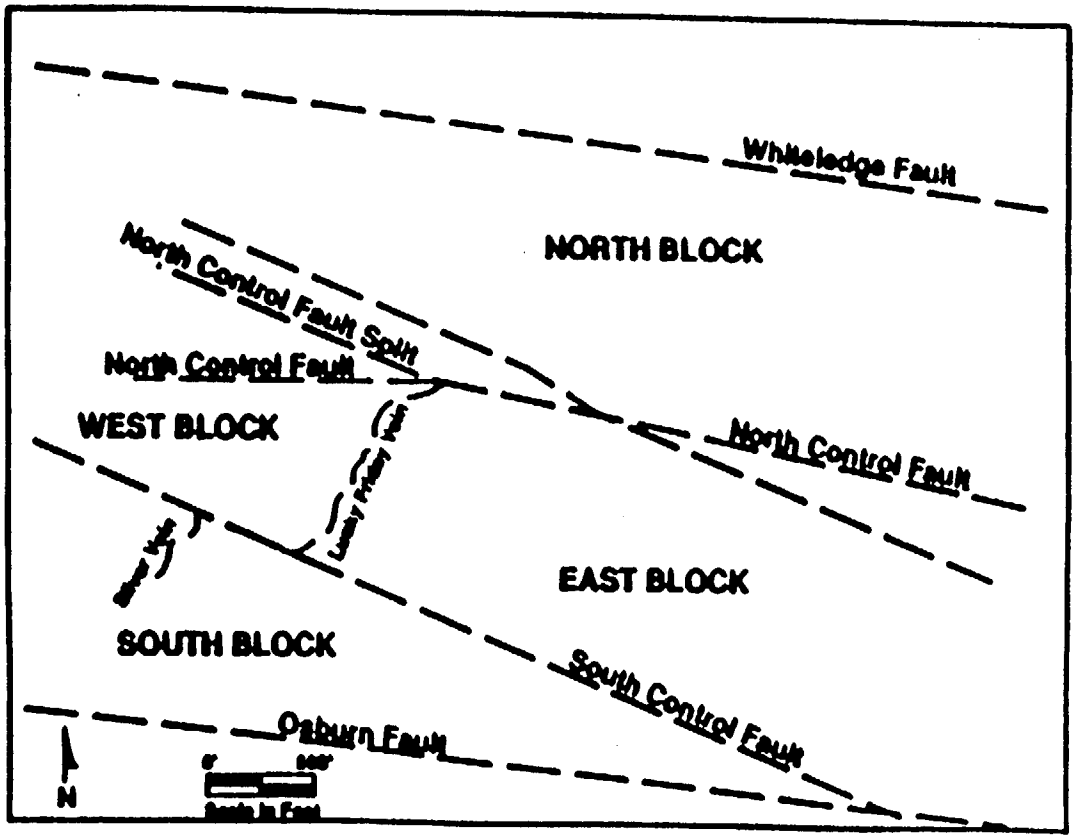
MULLAN, IDAHO

OBJECTIVES:

- **TO INVESTIGATE MECHANICAL RESPONSE OF UNDERGROUND MINE FACILITIES ASSOCIATED WITH SEISMIC EVENTS**

- **TO CLARIFY AND QUANTIFY THE RELATION BETWEEN SEISMICALLY-INDUCED GROUND MOTION AND CHANGES IN GROUNDWATER CONDITIONS**

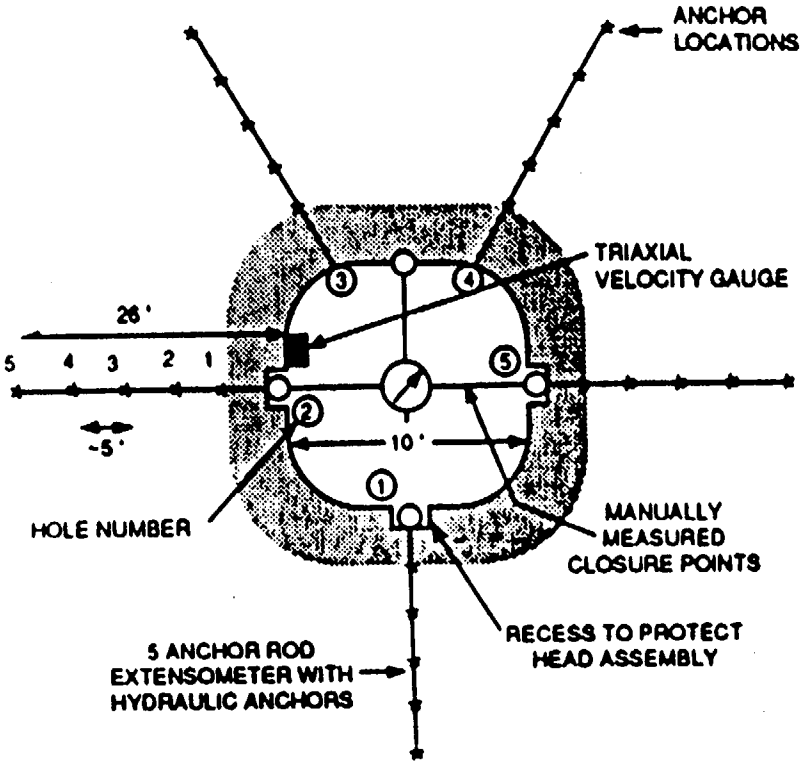
- **TO GENERATE A RELIABLE DATA SET TO DETERMINE IF ESTABLISHED NUMERICAL MODELS CAN ADEQUATELY DESCRIBE EFFECTS OF SEISMIC ACTIVITIES ON UNDERGROUND STRUCTURES AND GROUNDWATER HYDROLOGY**



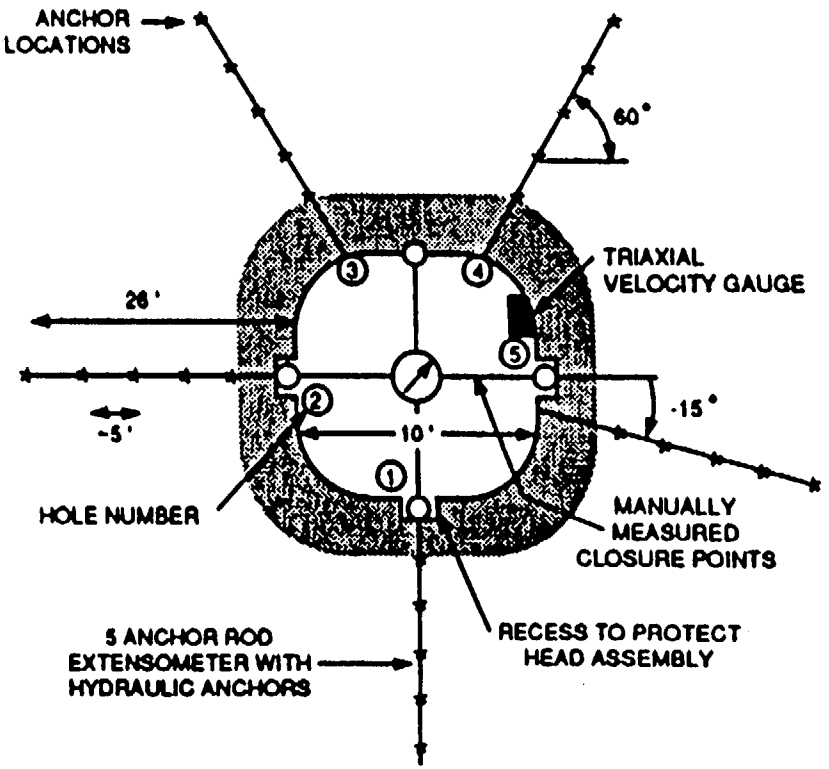
PLAN VIEW OF THE LUCKY FRIDAY OREBODY SHOWING FAULT STRUCTURES

EXCAVATION RESPONSE STUDY

- MEASURE ROCK DISPLACEMENTS AROUND EXCAVATIONS
- MEASURE CLOSURE OF EXCAVATIONS
- MONITOR SEISMIC WAVES AT THE LOCATIONS FOR INSTRUMENTATION



(a) LFM95-C1 Site

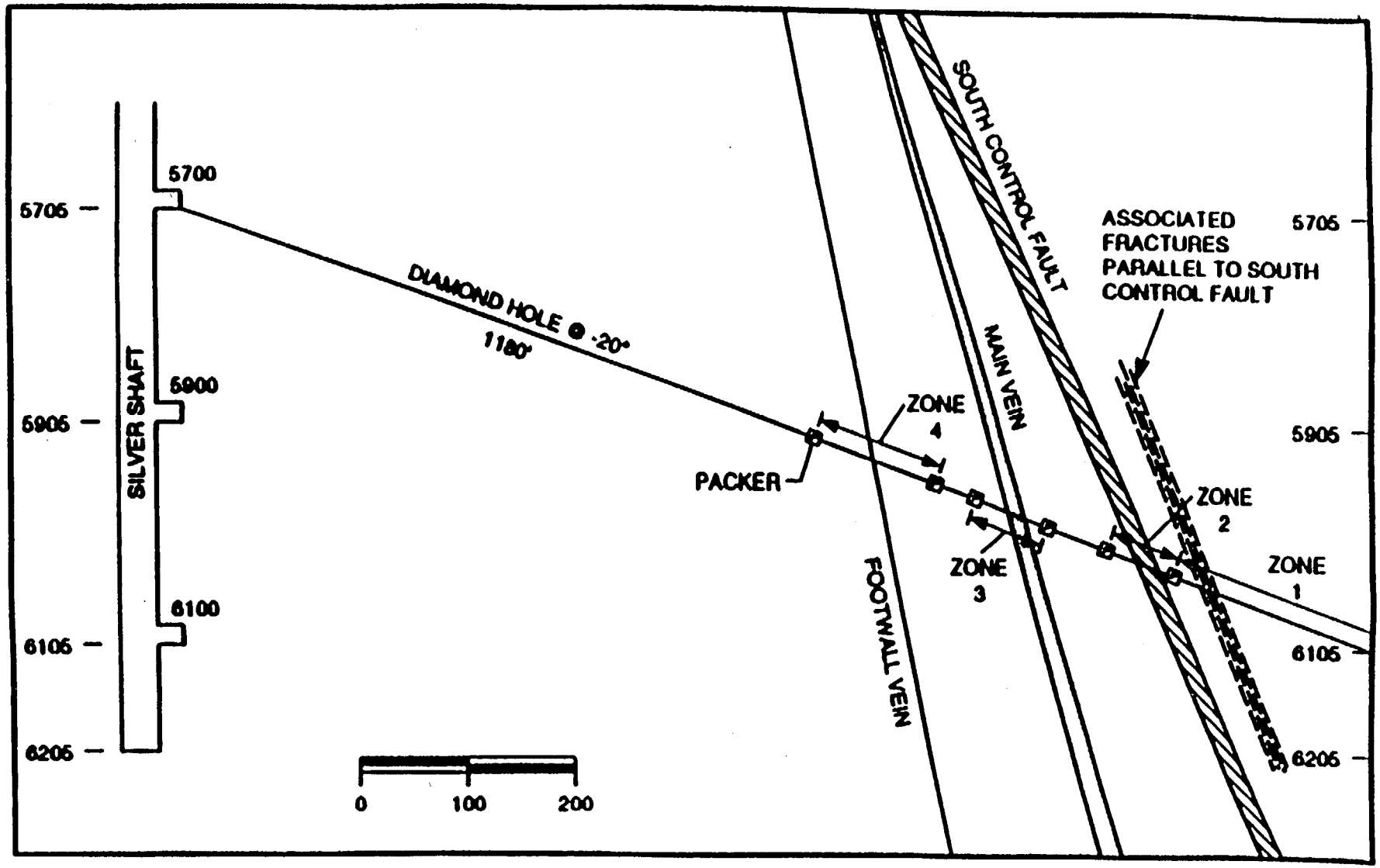


(b) LFM95-C2 Site

INSTRUMENTATION ARRAY FOR CROSS SECTIONS OF THE 5210 SUBLEVEL

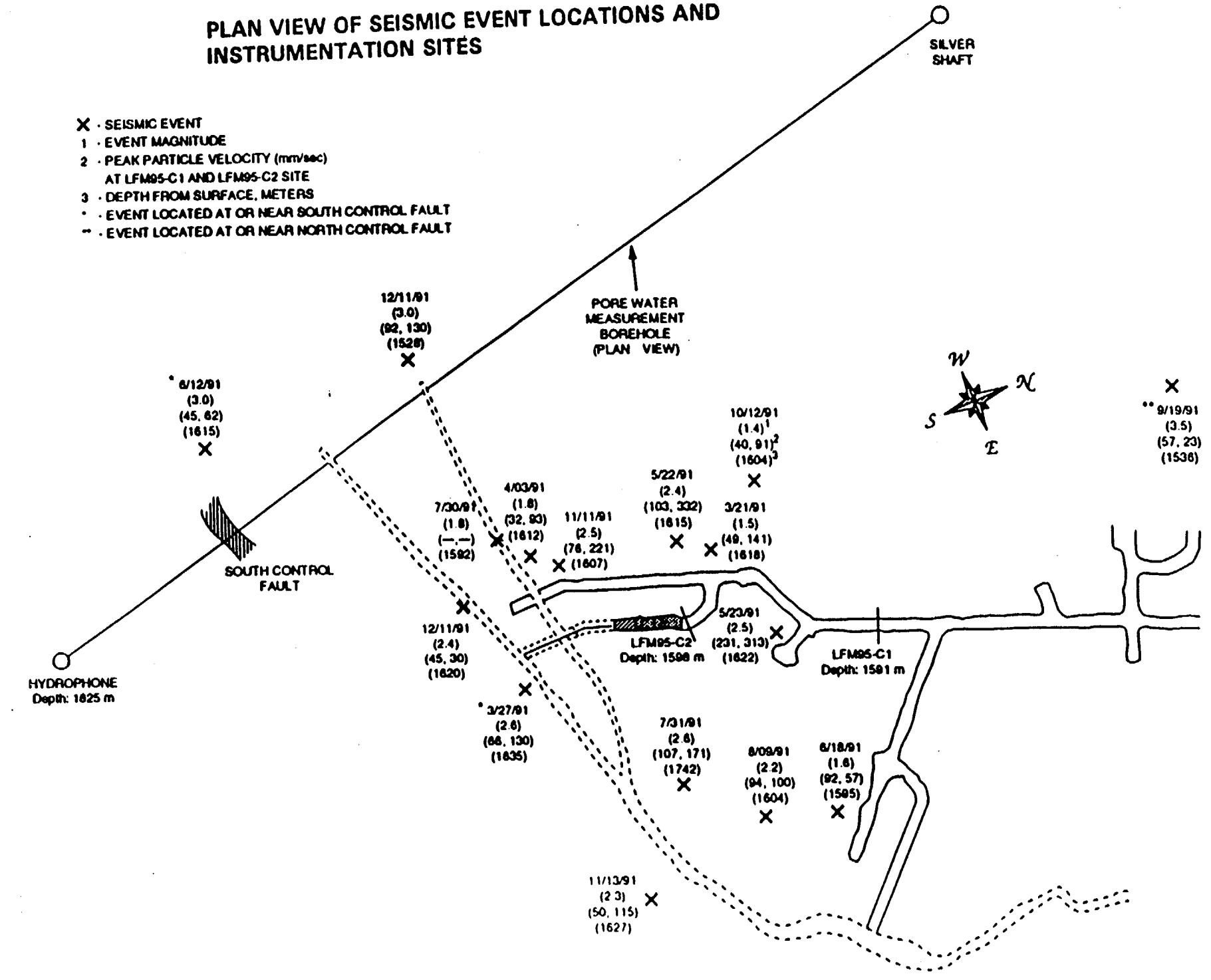
GROUND WATER CHANGE STUDY

- MONITOR WATER PRESSURE AT SELECTED GEOLOGIC FEATURES
- MONITOR GROUND MOTION ACCELERATION



LUCKY FRIDAY SILVER SHAFT CROSS SECTION DIAMOND DRILL HOLE FOR GROUNDWATER HYDROLOGY STUDY, LOOKING N 74° E

PLAN VIEW OF SEISMIC EVENT LOCATIONS AND INSTRUMENTATION SITES



SEISMIC/ROCK MECHANICS RESEARCH PROJECT

SUMMARY OF FIELD STUDIES ON THE RESPONSE OF ROCK & WATER PRESSURES TO SEISMICITY:

- o CAUSES OF ROCK DISPLACEMENT
  - SEISMIC IMPACT
  - MINING (STRESS REDISTRIBUTION)
  - BACKFILL OPERATION
- o OPENINGS DID NOT NECESSARILY RESPOND TO ALL SEISMIC EVENTS WITH HIGHER THAN "THRESHOLD" PEAK PARTICLE VELOCITY
- o OPENINGS AT HIGH STATE OF STRESS ARE MORE SENSITIVE TO SEISMIC EVENTS
- o JOINT STICK-SLIP MECHANISMS MAY BE USED TO EXPLAIN:
  - THE DIFFERENCE IN DISPLACEMENT CHANGES INDUCED BY EVENTS WITH SIMILAR PEAK PARTICLE VELOCITIES.
  - WHY OPENINGS SOMETIMES DO NOT RESPOND TO MINE SEISMIC EVENTS WITH HIGH ENOUGH PEAK PARTICLE VELOCITY.
- o CURRENT OBSERVATIONS INDICATE THAT GROUND WATER RESPONDED TO MINE SEISMIC EVENTS WITH MAGNITUDES GREATER THAN 2.0
- o GROUND WATER PRESSURES NORMALLY INCREASE AFTER A SEISMIC IMPACT, WITH ONE EXCEPTION
- o WATER PRESSURE CHANGES OCCURED IN ALL THREE ZONES THAT WERE PACKED OFF AS A RESULT OF SEISMIC EVENTS, WITH ONE EXCEPTION

Dec. 14 + 15 ACNW 16

[No recorder for transcript]

12/1/92 NSRRC Waste Subcommittee mtg
8:30AM – @ Crowne Plaza

M. Silberberg – introduction – purpose of meeting to present overview of Perf Assessment program in ~~morning~~ morning and an overview of Research Programs highlights in afternoon – all on HLW.

J. Youngblood ✓	N. Eisenberg ✓	J. Randall ✓
T. McCartin ✓	W. Ott	John Phillips ✓
T. Nicolson ✓	B. Morris ✓	Phil Reed ✓
R. Johnson ✓	M. Silberberg ✓	Ed O'Donnell ✓
Giorgio – (ACNW staff)	M. Federline ✓	
	Members of NSRRC.	

Question – ~~are~~ all of HLW program res. projects [and IPA] devoted to Yucca mtn.? ~~answer~~ answer much of work is generic

Eisenberg – said PA work is split about 1/3 each at DHLW, Res and CNWRA

Questions regarding interactions between PA and Research Program – doesn't PA help determine what work is done in Research? answer – yes.

Series of questions by Tourecotte
(T) Question – delay in PA – why? Federline answered shortage in staff – limits on hiring NRC staff.

Question - what is effect of impact of National Energy Policy Act of (1992). e.g. dose based standard.

Tourecotte - what if have catastrophic disruption (e.g. volcano) but it is a low probability event 1 in 10,000 do you really think the site is licensable? Should consideration of this be inherent in P.A.

Question of use of peer review in examining results of PA. modelling

M. Federline continued to stress that PA phase 1 & 2 to assess development capabilities.

Tourecotte asked about SRA - is there does descriptive material exist on SRA - answer yes big silhouette but no elaboration occurred.

break

Tim McCartin

Tourecotte - expressed concern on site characterization data are we just plugging in numbers into equations without understanding data

Another Question — ~~Does~~ If we have inadequate data from DOE don't we have such large uncertainty that modeling is useless. If uncertainties are so great we can not distinguish deciving ~~Forces~~ forces.

Questions Toureod on precipitation and relation to infiltration and do we consider just steady state flow or also transient flow (infiltration).
also asked if ~~we~~ NRC is ~~does~~ looking at changes in precipitation over 10,000 years.
Question on - is NRC doing research on climatic change W. Ott noted support of NSF projects he also noted $ow had been given to Center but there is a question on whether is Center can or wants to do the work. Nicolson noted counting on NSF project + work at Brown Univ.
McCarthy described PA Res activities at Center.

International Hydrologic Validation programs — a problem in part was inability to retest The programs provided data sets but always some pertinent parameter were not measured and modelers found "tweak" model to fit data but could not retest / collect additional data — INTRAVAL did improve on this.

What data set could be used to validate entire PA model" answer — probably can validate certain pieces but probably can not validate whole PA system model. Question — or use of Natural Analogs would have to do "complete site characterization at site"

---

*Mr. George Segas
part *Dr. Themis P. Speis
Prof. Fred J Molz (Chair)
Mr. C.J. Heltemes, Jr.
Dr. Richard C. Vogel
Mr. Bernstein

*Dr. Thomas Boulet
Mr. Edwin E. Kim
Dr. Donald Turcot
Prof Herbert S. Isbe

most comments by Bernstein & Turcott

Lunch Break

12/1/92
afternoon

T. Nicolson -
- Progress in Hydrology Research
Q. - what do you mean by saturated?
[comment it is much different for geochem vs hydrology]
Q - has the geology, particularly fractures, at Apache Leap been characterized. - A. yes by early study for Magma mine, By USGS, and at test site by Univ of Az.

Q - of Univ. Az determining total flow ~~into~~ (volumetrically) into magma headgate tunnel. - (A.) no!
(Q) but don't you need to know total volume of flow to model this system? (A.) we are not modeling entire water budget/flow
(Q) but isn't that what you really want to do. NRC/DOE Az is approaching this in steps like site characterization
(Comment) May not require alot more work to answer many broader questions at Apache Leap.

* Tom Nicolson - noted NAS Report just read this -

L. Kovach

Q – what is meant by Quaternary?
Unit of Geologic Time – Last 1.6 my

Q – where is Climax facility located?

Q – why unit repository being sited in NE Nev. in tectonically/volcanically very active area?

Q – are there other activities in developing predictive models –
yes –
Shaw – Hawaiian volcanoes
?? – Iceland
other USGS

Q – what makes you think that you can be successful with the approach being used –
A. data has not been compiled and assessed.
Q – Is that NRC's job
A – yes. Kovach believes need to look at driving mechanisms at Regional scale – DOE will look at site more specifically.
Subcommittee – thought should build up data base and then statistically project to obtain probabilities for occurrence.

7./

Suppose DOE submitted License Application today — ~~Could~~ How long would it take you to do work so you could review License application.

Burnstein - ~~Any~~ directly voted ~~that NRC should not~~ there is a circle with NRC and DOE blaming each other for not getting work done so program can advance.

Birchard

CalTech / Smithsonian Project

- use GPS to investigate contemporaneous deformation rates.

Q - when will we get the first data?

A - depends on rates - but probably in next year or two

Q what is expected maximum rate of deformation?

Comment - are optimistic that GPS can give good data in reasonable (2-3 yr.) time - with 2-3 mm/yr resolution

Davis - good ~~geodetic~~ geodetist (GPS) to compliment Wernicke

Bischel – Geochem Res. Project

Burnstein – notes inconsistencies between saying canister will be substantially complete for 300 – 1000 years but then Geochemistry indicates will not have containment and will have release.

Q – he keeps looking for prioritization of radioactive elements – A. Sarkis has done this.

Q. how wet will rocks be?

Comment – Chemistry of uranium is not particularly the same as the actinides – so why is the Center working on U. Are we working on it because it is easy to work on. Will we really have to, in the end, investigate the actinides after all.

Answer will be large amount of U in system need to understand its behavior.

Analogs – L. Kovach 9/

Subcommittee – very interesting

Q who gets to go to Santorini

Q What is status of Alligator River Analogs Project –
surprise modeling – for exchange
monitor wakulla well –
integrated approach

Thermohydraulics – J. Randall

Q – have we done experiments above boiling temperature –

A No, my program to those include temps above 100°C

Q Didn't Drew Gough used for natural analogs show temps ~~above~~ of 250°C?

Q what phenomena were we trying to elucidate

Q Cancel the subcommittee meeting see the peer review panel report and letters (Randall mentioned that each member of panel submitted letter)

NOTE

Burnstein — desired additional info for panel members on thermohydrology experiments — and he so requested from Chairman (mo/z0)

Comments on fusing beads concern on "pressing up" experiments. Why didn't we throughout experimental set

to Morris Compersonally

mo/z* people have been studying characteristic curves for 20–30 years without success. Is difficulty with fundamental theories. Is tendency for more complicated models.

Were significant subcommittee comment and expression of state of concern.

Turcotte — indicated he had problem with glass beads fusing when doing similar experiments

11./

Jake Phillips
Seismic Rock Mechanics

Discussed Lucky Friday Mine work

Garner Valley Project
Originally reactor related work — now joint French-DOE to start in Feb/93

M. Silberberg

HCNRes is revising Research Plan.

Q— What is the ACNW.
ACNW is not mandated by Congress and serves at pleasure of the Commission

Q How do you assure that you (ACNRes) is doing the right kind of work?

A: From Interactions w/ DOE, i.e. Technical Exchange and meet with DOE — approx 4 mtgs

· Conduct workshops & Nat Analogs

Participate in NWTRB & ACNW

Participate in Potential meetings.

Comment

- serious problem with integration of technical disciplines.

Burnstein - noted evolution and uniqueness of development of PA capabilities at NRC especially in context of COF and development of the Center

** will be a report prepared for the Full NSRRC

Molz will prepare report

205/ 844-6290 FAX

" " -6268 phone

He requested comment from Subcommittee members and from anyone else.

Agenda
NSRRC Waste Subcommittee
Meeting, December 1, 1992

A.M.

8:30 am	Introduction and HLW Research Program Planning Update	M. Silberberg
8:55 am	Overview of NRC HLW Iterative Performance Assessment Program - Objectives - Roles of NMSS, RES, CNWRA - Status of HLW-IPA Phase 2	N. Eisenberg(NMSS)
9:40 am	BREAK	
10:00 am	HLW Performance Assessment Research Program	T. McCartin
12:00	LUNCH	

P.M.

HLW Research Program Overview Update

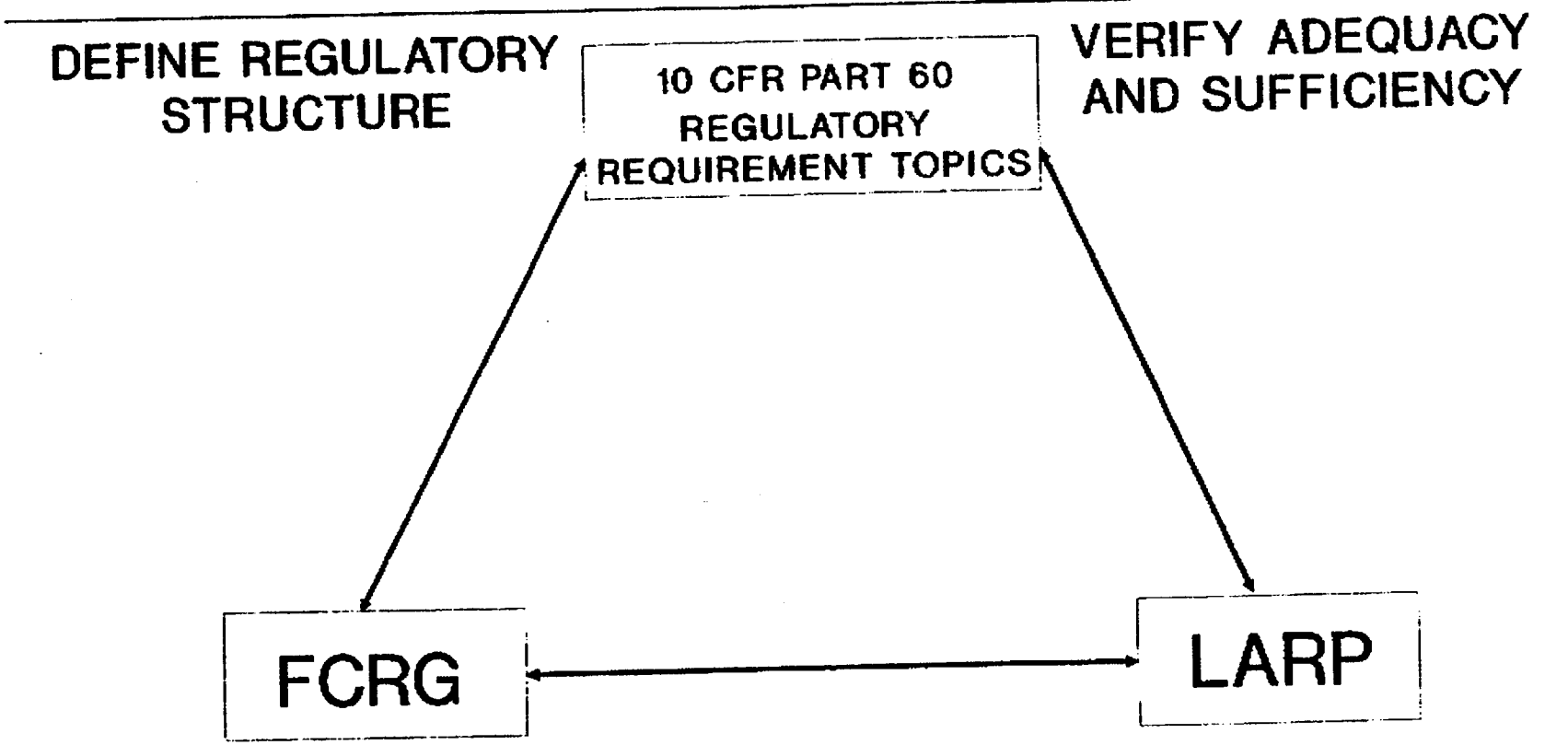
1:15 pm	Hydrogeology	T. Nicholson
1:40 pm	Volcanism	L. Kovach
2:05 pm	Tectonics	G. Birchard
2:30 pm	Geochemistry	G. Birchard
2:50 pm	Natural Analogues	L. Kovach
3:15 pm	BREAK	
3:30 pm	Thermohydrologics	J. Randall
3:55 pm	Seismic Rock Mechanics	J. Philip
4:20 pm	Summary	M. Silberberg
4:30 pm	Executive Session	Subcommittee
5:30 pm	ADJOURN	

b:\nsrrc.ms

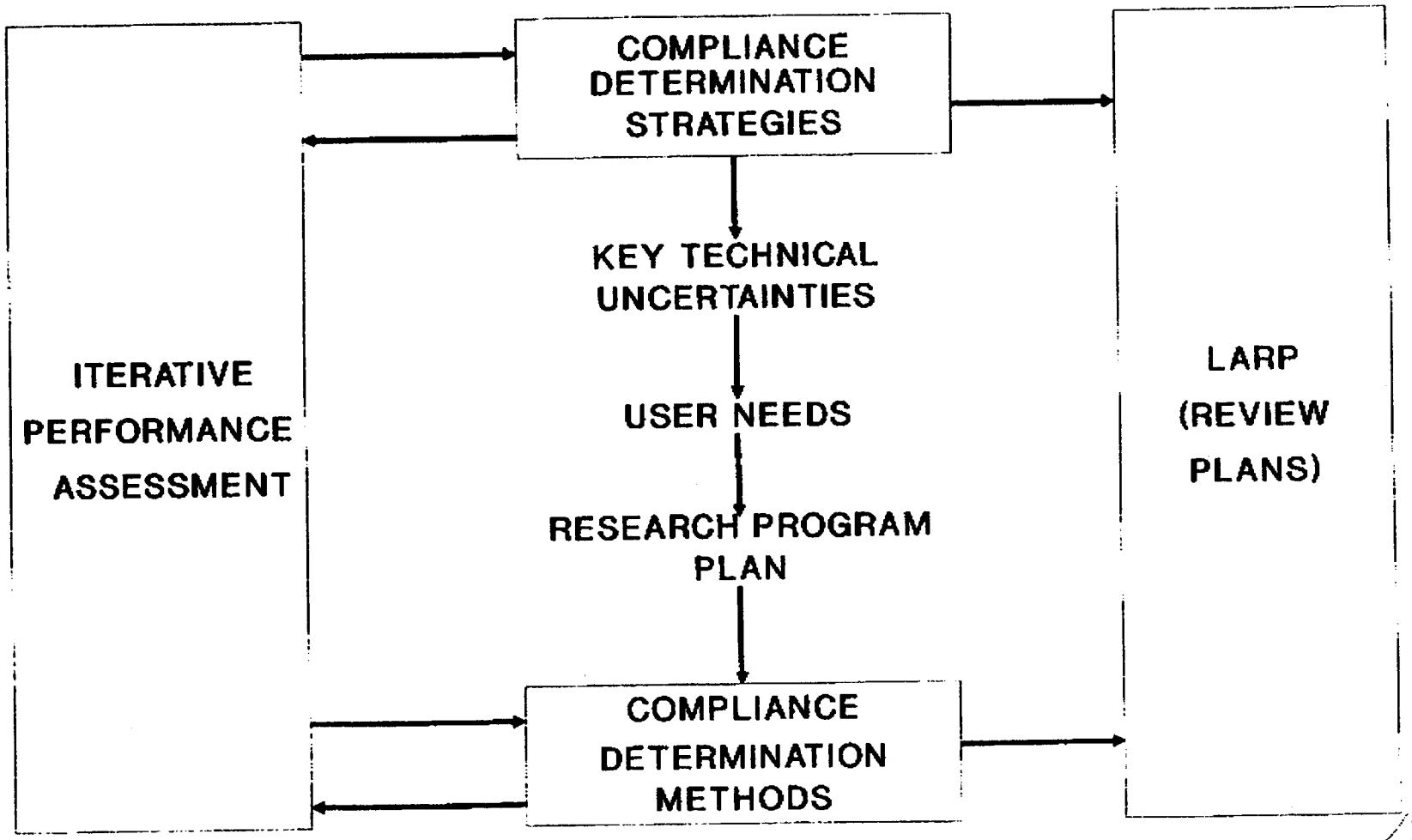
RELATIONSHIP OF MAJOR REGULATORY DOCUMENTS
TALKING POINTS

- DHLWM regulatory program goal
  - Base regulatory program on a consistent organizing structure for the requirements in 10 CFR Part 60
- Primary regulatory products based on the consistent organizing structure
  - Definition of regulatory requirement topics
  - Guidance to DOE on the format and content of the License Application (FCRG)
  - Guidance to the NRC staff on review of DOE's License Application (LARP)
- Other benefits derived from the regulatory structure
  - Regulatory/Institutional uncertainty identification and resolution
  - Regulatory guidance (SP, STP) linked to a specific regulatory need
  - Streamlining of the HLW repository licensing program by providing regulatory products based on consistent format, content and analyses

GENERAL RELATIONSHIP OF MAJOR REGULATORY DOCUMENTS



INTEGRATION OF THE RESEARCH PROGRAM PLAN WITH DHLWM REGULATORY PROGRAM AND USER NEEDS



INTEGRATION OF THE RESEARCH PROGRAM
TALKING POINTS

- Compliance Determination Strategy
  - Each CDS is directly tied to both 10 CFR Part 60 and a Review Plan in the LARP.
  - Strategy for review of compliance demonstration for a set of regulatory requirements
  - Identifies and describes key technical uncertainties

- Key Technical Uncertainties
  - Questions of "How To" describe, evaluate, or understand an aspect of repository siting, design, construction, or performance
  - Those technical uncertainties which have reasonable likelihood of occurrence and significant impact on repository performance should they occur
  - Evaluate for definition of DHLWM Research User Needs

- DHLWM Research User Needs
  - Incorporated into the Research Program Plan
  - Combined, as appropriate, into specific Research Projects (which may have multiple objectives)

- Implementation of the Research Program Plan leads to development of Compliance Determination Methods and Confirmatory Data for use in License Application reviews. Note: Results feed directly into specific Review Plans

- Compliance Determination Methods
  - Detailed review methods for evaluating compliance demonstration for a set of regulatory requirements
  - Contain acceptance criteria, review responsibilities, interface and integration requirements, and example evaluation findings

- Portions Of CDSs and CDMs are contained in Individual Review Plans in the LARP

- IPA influences and is influenced by CDS and CDM development
  - Identification/Refinement of specific technical uncertainties
  - Assessment of importance/priority of uncertainties by means of sensitivity analyses
  - Focuses on the impacts on performance

INTEGRATION OF THE RESEARCH PROGRAM
TALKING POINTS Cont'd.

- CDS and CDM development is iterative based on results of IPA and evaluation of the research program
- CDS development is scheduled for initial completion in FY93
- CDM development is scheduled for completion during FY94-97
- These products and processes all influence each other and are designed for iteration and refinement

UAZ STUDIES ON SCALE EFFECTS & FINGERING

- Development & Testing of "Universal Scaling" Theory
  - Development of Scaling Rules for Estimating Effective Parameters over a Range of Scales (upto Repository Scale)
  - Investigation of the Influence of Geostatistical Variability on Contaminant Transport
  - Review Theoretical & Field Data for Understanding Conditions Responsible for Unstable Flow in Unsaturated Media
  - Formulate Concepts for Defining Unstable Flow Conditions Resulting in Preferential Transport in Unsaturated Fractured Rock

REGIONAL HYDROGEOLOGIC STUDIES

- Integration of Regional Geology, Geophysics, Hydrology & Ground-Water Chemistry in Development of Conceptual Hydrostratigraphic Flow Models
- Evaluate Methods to Formulate Regional-Scale Evapotranspiration & Recharge Mechanisms in Thick Unsaturated Zone
- Evaluation of Regional Hydraulic Gradients
- Application of Numerical Techniques Including Parameter Estimation on a Regional Scale
- Examination of Methods to Confirm Regional Ground-Water Flow Models
- Review Adequacy of 2D VS 3D Flow Modeling on a Regional Scale

HYDROLOGY RESEARCH ACCOMPLISHMENTS

- Development of a Universal Scaling Theory (*WRR* Article)
- Review of Earlier DOE Field Heater Experiments & Development of Technical Considerations for Design of a Large-Scale Coupled Effects Study (NUREG/CR-5880)
- Documentation and Bench Marking of the *BIGFLOW* Code and Later Coupling to *SLIM* (Particle Tracking Code) (NUREG/CR-XXXX)
- Characterization & Analysis of Fracture Set Geometries & Hydraulic Properties for Matrix & Fracture Components in Rock Samples from the Apache Leap Tuff Site (NUREG/CR-5239, 5482, 5581 & 5596)
- Assessment of Hydraulic, Pneumatic and Geochemical Testing Methods and Instrumentation in Fractured Rock (NUREG/CR-XXXX)
- Documentation of Approaches for Modeling Large-Scale Unsaturated Flow in Heterogeneous, Stratified & Fractured Geologic Media (NUREG/CR-5743)

PROGRESS IN TECTONICS RESEARCH

PRESENTED TO THE
NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE
1 DECEMBER 1992

PRESENTED BY
GEORGE F. BIRCHARD
USNRC OFFICE OF RESEARCH
tel. (301)492-3864

Progress in Volcanology Research

Presented to the
Nuclear Safety Research Review Committee
1 December 1992

Presented by
Linda A. Kovach
USNRC Office of Research
tel. (301) 492-3869

Volcanic Systems of the Basin and Range Research Project

REGULATORY BASIS

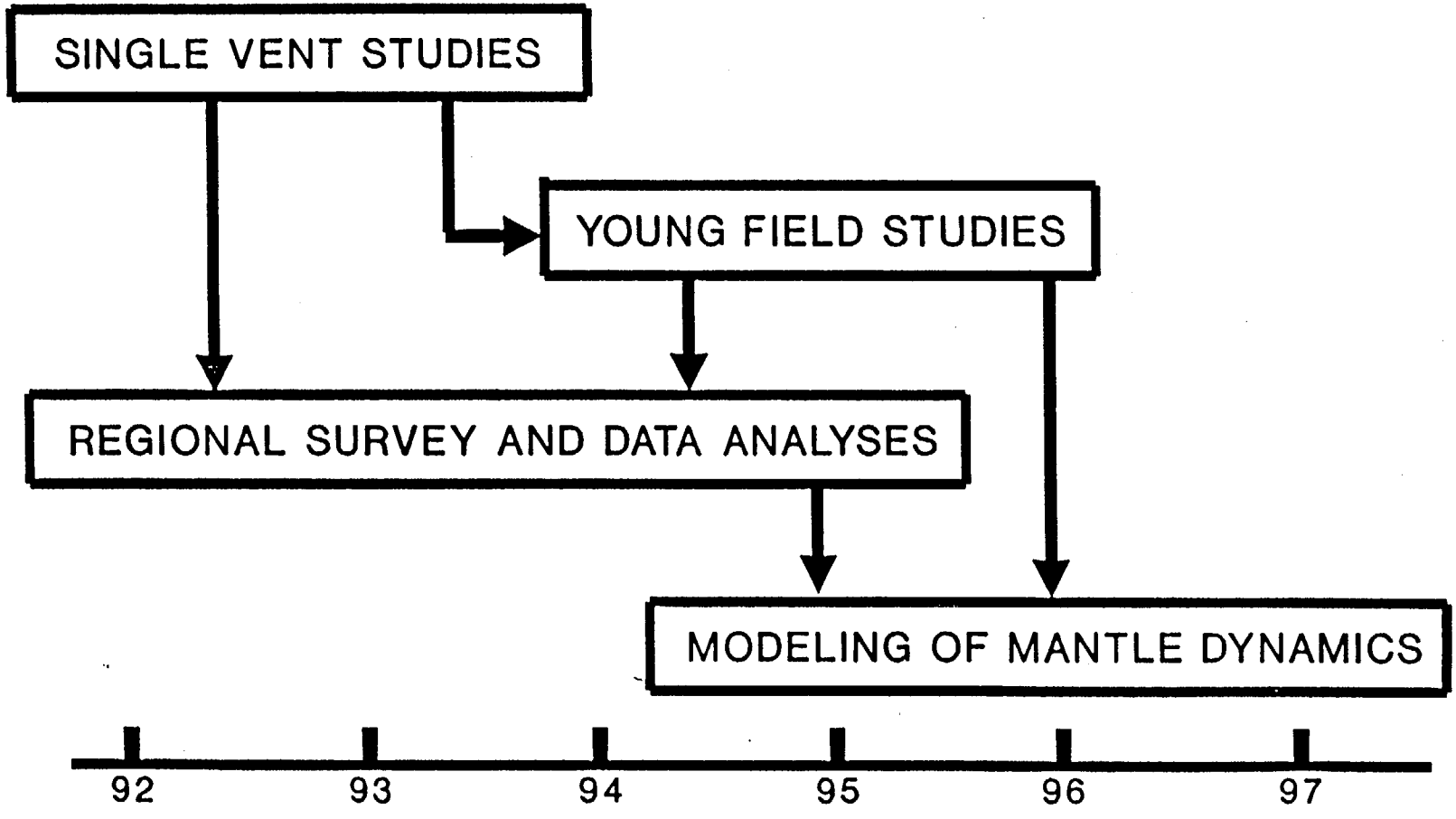
10 CFR 60.112 Overall System Performance Objective - Geologic Repository

10 CFR 60.122(c)(15) Potentially Adverse Condition: Evidence of Igneous Activity in Quaternary

NMSS USER NEEDS ADDRESSED

- Spatial and Temporal Distribution of Igneous Activity
- Mechanisms and Processes Controlling Magmatic Activity

RESEARCH PROGRAM ON VOLCANISM



Volcanic Systems of the Basin and Range Research Project

Objectives:

- 0 Provide Technical Basis, Expertise & Analytical Tools for Oversite of DOE
  - Site Characterization
  - Design Evaluation
  - Volcanic/Magmatic Hazards Scenario Analyses
- 0 Support development of Regulatory Guidance Documents on Volcanic/Magmatic Hazards at Yucca Mountain

Volcanic Systems of the Basin and Range Research Project

Technical Activities

Task 1: Literature Review of Regional Volcanic/Tectonic Activity 6 ma.
(CNWRA Report 92-025 issued 9/30/92)

Task 2: Development of Computerized Database for:
- Review of DOE Reports and L.A.
- Evaluation of DOE Conceptual Models for Volcanic/Magmatic Hazards

Task 3: Assessment of Existing Data (Completeness, Uncertainties, Age Determination Techniques) and Models (Analytical Methods, Assumptions)

Task 4: Development of Volcano/Tectonic Models

Volcanic Systems of the Basin and Range
Research Project Milestone Chart

Tasks	FY 92	FY 93	FY 94
Task 1: Literature review	completed 9/92		
Task 2: Database Compilation	initiated	>--------->	complete data comp report 1/94
Task 3: Review DB		initiate 1/93	complete 6/94
Task 4: volcano/tectonic models		initiate 4/93	complete 9/94

Volcanic Systems of the Basin and Range Research Project

Task 4: Analysis of Database and Model Development

- Analyze database for Spatial/Temporal Correlations Magmatism/Volcanism -Tectonism:

  - Predictable Patterns of Volcanic Activity

- Development of Mechanistic models based on analysis of database

Field Studies of Basaltic Disruptive Scenarios Research Project

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Objective:

1) Increase understanding of subsurface magmatic structures and adequacy of geophysical site characterization techniques used to identify subsurface magmatic structures.

2) Determine style of basaltic volcanic eruptions and near surface magmatic events which could potentially disrupt a HLW repository. Identify driving mechanism for basaltic volcanic events including such issues as initial volatile content versus interaction with wall rock and groundwater.

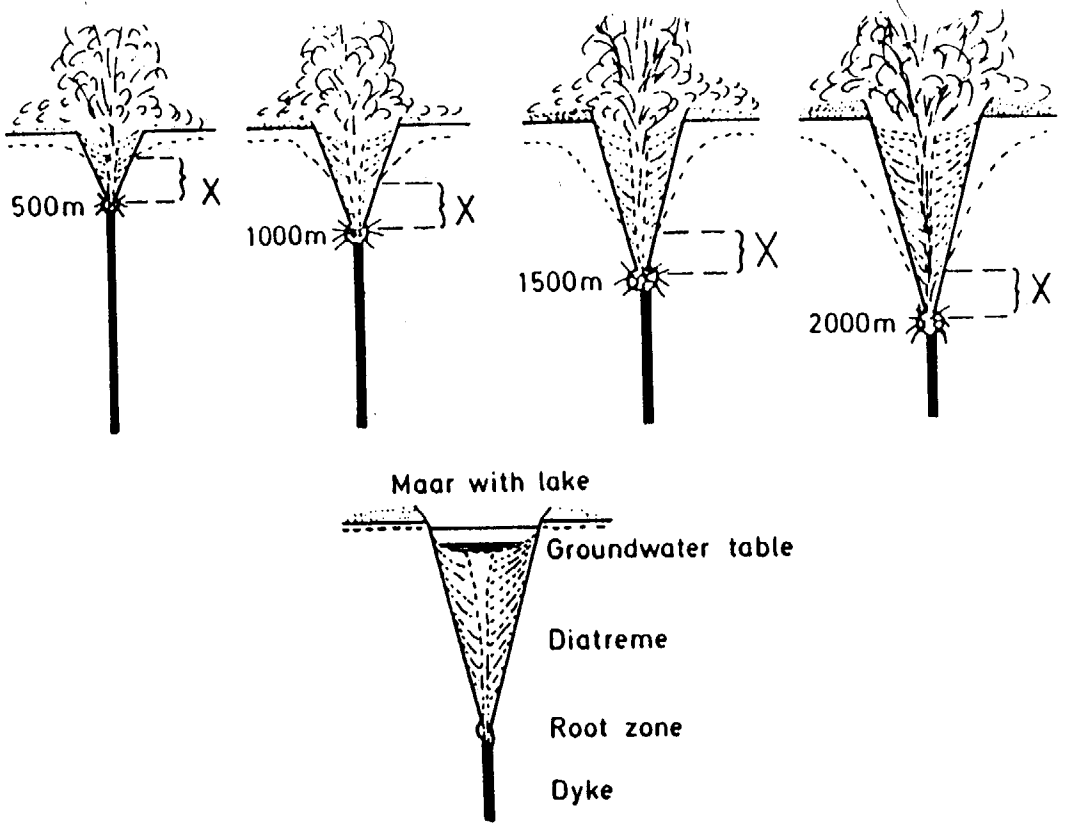

Fig. 5. Schematic drawing showing evolution of a maar-diatreme volcano by confining pressure control assuming restricted availability of groundwater and thus formation of a cone of depression during phreatomagmatic activity. Because of hydrostatic pressure dependance of the water vapour explosions — a confining pressure barrier of about 20–30 bars is assumed — the diatreme penetrates downward with time, leading potentially to a diatreme 2000–2500 m deep. *X* gives assumed maximum depth of groundwater column on water vapour explosion site. After the eruptions cease, the groundwater table may restore itself to the original levels, usually leading to formation of a maar lake

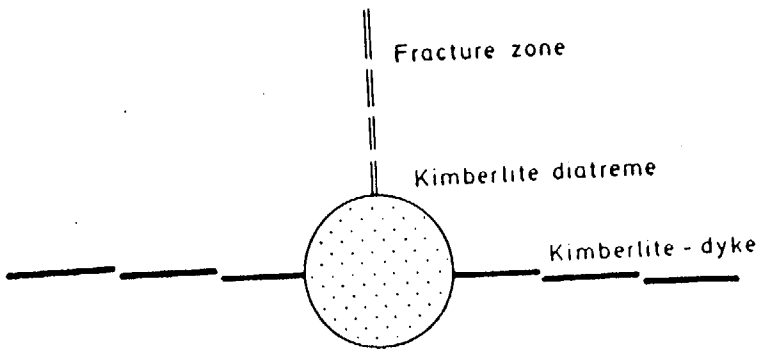

Fig. 6. Relationship between some kimberlite diatremes (filled with clastic rocks) and associated igneous kimberlite dykes (called precursor dyke; Clement 1982). The diatreme is located where the dyke intersects a zone of structural weakness. The diatreme is assumed to have formed where magma rising within the dyke fissure intersected groundwater circulating within the zone of structural weakness at the time of volcanism. For com-

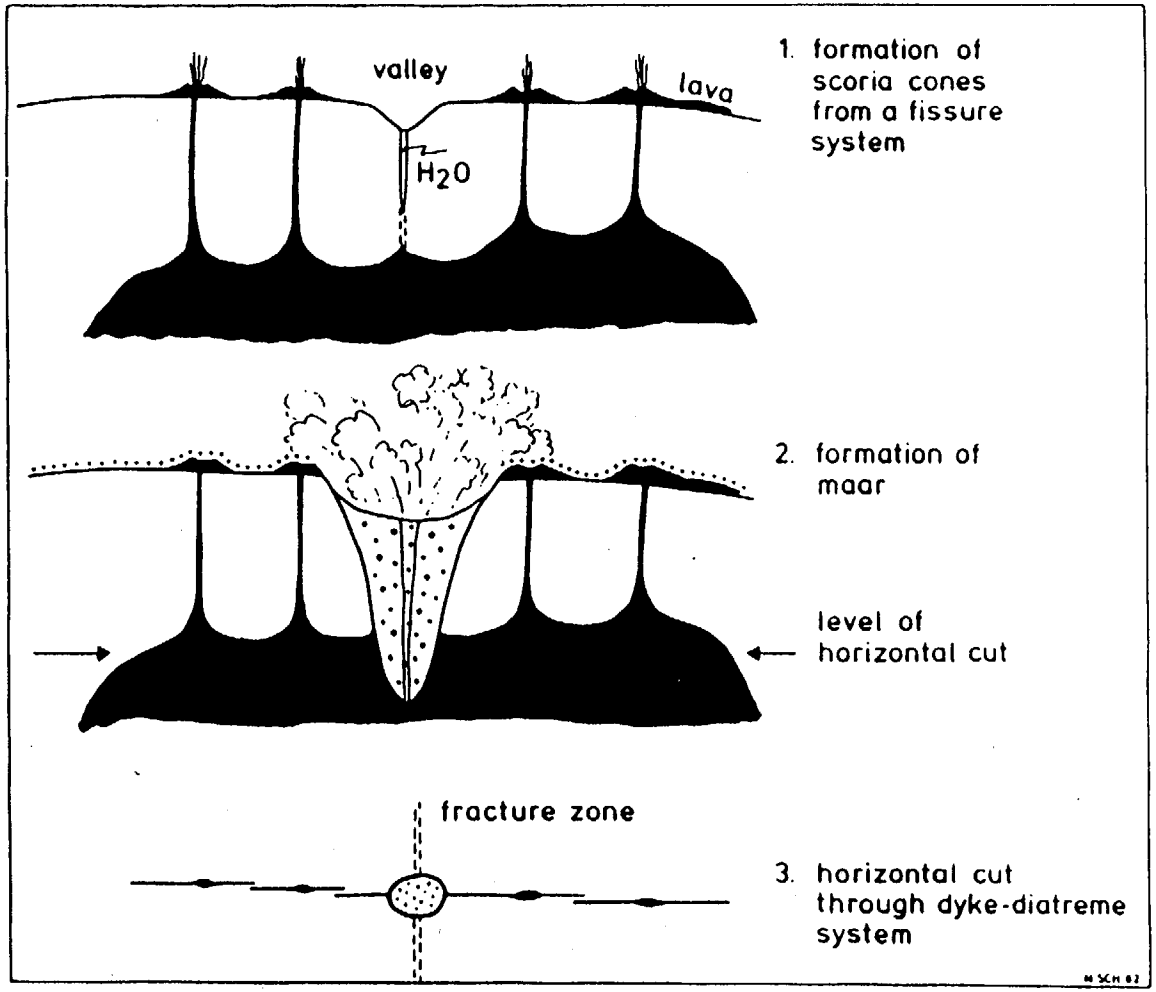

Fig. 7. Schematic vertical and horizontal sections along a volcanic system with scoria cones and a maar fed from the same dyke system. The Bad Bertrich volcanic system of the Westeifel volcanic field (Lorenz and Büchel 1980a) has been taken as basis for this diagram. Formation of a maar followed formation of the scoria cones when magma rose within the dyke fissure into a hydraulically active zone of structural weakness (represented at the surface by a valley) and contacted groundwater. If for instance 300 m of surface rocks were to be eroded, a map would show the volcanic system as a dyke system with a diatreme located where the dyke intersects a zone of structural weakness. Thus, in the Eifel, erosion would lead to a dyke-diatreme relationship as is found in the kimberlite diatremes and dykes in South Africa (see Fig. 6)

Field Studies of Basaltic Disruptive Scenarios Research Project

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Approach: Field and Laboratory Studies

Task 1: Identification of field sites for study.

Task 2: Investigation of Subsurface Magmatic Plumbing systems for small volume Basalts.

Task 3: Identification of Eruptive Phases and Potential Disruptive Consequences

Task 4: Investigation of Volatiles and Hydrothermal Alteration.

Field Studies of Basaltic Disruptive Consequences Research Project

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Status: SOW in final stages of preparation has been reviewed by NMSS

Products: Data and models to assess basaltic disruptive scenarios

Direct input to NRC's IPA efforts