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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: EPRI Workshop on Performance Assessment. (Account No. 20-3702-065)

DATE AND PLACE: EEI, Washington, D. C., December 4-6, 1990

AUTHORS: Budhi Sagar and Renner Hofmann

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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: EPRI Workshop on Performance Assessment

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AUTHORS: Budhi Sagar and Renner Hofmann

PERSONS PRESENT:

Participants represented DOE, NRC, ACNW, NWTRB and others. Attendance list for December 4th is attached.

BACKGROUND AND PURPOSE OF TRIP:

The Electric Power Research Institute (EPRI) was the organizer of the workshop. The agenda consisted of presentation of performance assessment approaches by EPRI, Golder Associates (under contract to DOE Headquarters), NRC and DOE's Yucca Mountain Project Office. Agenda also included discussion on adoption of workshop format for exchange of ideas on performance assessment in the future.

SUMMARY OF PERTINENT POINTS:

- Using a workshop format, EPRI has developed an approach for performance assessment. Their work has been going on for about a year. The EPRI approach depends heavily on assembling experts in different disciplines and interacting in periodic workshops. Apparently this format is similar to the one that EPRI used successfully in investigating seismicity issues related to reactor design.

- Golder Associates, under contract to DOE Headquarters, is also developing an approach for doing integrated system performance assessment. This approach is only partially developed for lack of funding.

- DOE's Yucca Mountain Project Office (YMPO) is investigating site suitability at a high priority. YMPO did not present an approach that resembled any of the approaches presented at the workshop.

- The NRC presented results of its Phase 1, Iterative Performance Assessment.

SUMMARY OF ACTIVITIES:

December 4, 1990

Dr. Robert Shaw of EPRI presided over the workshop. He introduced the EPRI performance assessment approach developed over a period of about a year. The EPRI approach consisted of assembling a group of experts (one expert per major discipline) and discussing issue resolution in workshop formats. This format was used to develop a master logic tree, each node of which represents a process or event. Each node is then further expanded into its own logic tree. Probabilities are assigned to each branch of the tree. Depending upon the number of nodes in the tree, the number of end branches can be quite large. Consequence for each end branch is then presented as a CCDF. Some sensitivity analyses were also presented. The EPRI model is PC based and is obviously greatly simplified and depends heavily on expert judgment. Some details of the earthquake scenario were also provided. The EPRI speakers were: Bob Shaw, Robin McGuire (Risk Engineering, Inc.) and Kevin Coppersmith (Geomatrix). The EPRI results showed that out of the very limited number of isotopes considered, Neptunium resulted in most releases. A copy of the EPRI's summary presentation is attached.

Drs. Ian Miller and Bill Roberds of Golder Associates Inc. presented the approach to integrated performance assessment that is being developed for DOE Headquarters. It was suggested that the approach will find its use in determining site suitability and in updating the SCP. The Golder approach is to link a number of component models together. This approach includes accounting for "model error" which will be determined by experts. Only some components of the approach are ready at this time. Golder is looking for funding for further work on this approach. Copies of Golder presentation are appended.

December 5, 1990

A number of speakers from DOE presented the ongoing site suitability study to which performance assessment provides some input. Dr. Russ Dyer (YMPO) introduced the subject. There are two aims of the site suitability study: 1) to reevaluate existing data and judge site suitability, and 2) to prioritize tests for early detection of disqualifying conditions. Drs. Jean Younker (SAIC) and Larry Rickertsen (Weston) explained the development of site suitability measures. These measures are somehow based on performance measures, but are not the regulatory performance measures themselves. Dr. Art Ducharme (SNL) gave an overview of DOE's activities focused on determining site suitability. The basic approach consists of constituting expert teams to provide judgments on various issues. Dr. Judd (Decision Analysis Company) provided details and some examples of the application of decision analysis methods for prioritizing tests in the context of discovering disqualifying conditions. Copies of DOE presentations are attached.

Drs. Seth Coplan and Norm Eisenberg (NRC) gave a brief description of the NRC's Phase 1 performance assessment work. It was pointed out that the NRC's main objective in conducting this work was training of staff.

The audience were divided into five groups to discuss the usefulness of the workshop and to recommend how future workshops should be structured.

December 6, 1990

Discussion continued on future workshops. It was pointed out by a number of participants that EPRI does not represent a neutral party in the repository debate. Perhaps for this reason, the state of Nevada did not participate in this meeting. It was suggested that some other sponsor (ACNW, NWTRB, and professional societies) for these workshops may be found. However, EPRI's purpose in conducting this workshop was to further the process of site investigation and licensing. Thus, it wants to use these workshops for obtaining agreements and endorsements of approaches and methodologies. This will require that the workshops not be mere presentations, but working sessions. NRC expressed its reservations on such aims as it has some statutory responsibilities which require that it maintain its independence. It seems that the EPRI will hold at least one more workshop, probably in March 1991. Some of the outstanding issues regarding the format and sponsorship of the future workshops will be ironed out in that workshop.

IMPRESSIONS/CONCLUSIONS:

EPRI's work was supported and funded by the utilities. Their objective appears to be to encourage the DOE to undertake similar efforts and also to aid the DOE in getting some consensus on difficult technical issues. It was made amply clear that development of performance assessments was DOE's responsibility and not EPRI's. However, it seemed that EPRI would like to extend its approach further. However, it may be difficult for EPRI to sustain its efforts with its present funding sources. If the EPRI workshop format develops such that these will become working sessions, NRC will be able to participate only as observers.

PROBLEMS ENCOUNTERED: None

PENDING ACTIONS: None

RECOMMENDATIONS:

It is expected that the agenda for the March workshop will be available in advance. A decision to participate in that workshop should be taken based on that agenda. While it will be useful to keep track of EPRI's work, we may be able to skip some of the workshops without a great loss.

SIGNATURE:

R. Hofmann
Sr. Research Scientist

REFERENCES:

1. Attendance sheet.

2. Agenda.

3. Yucca Mountain Site Suitability by Golder Associates Inc.

4. Repository Development.

5. EPRI/EEI HLW Methodology Development Project.

6. Overview of DOE's Activities to Focus Testing Program on Site Suitability, by J. Younker and L. Rickertsen.

7. Overview of DOE's Activities to Focus Testing Program on Site Suitability, by J. R. Dyer.

8. Overview of DOE's Activities to Focus Testing Program on Site Suitability, by A. Ducharme.

9. Overview of DOE's Activities to Focus Testing Program on Site Suitability, by B. Judd.

10. Statement of Project Objectives.

CONCURRENCE SIGNATURES AND DATE:

B. Sagar — 12/27/90
Manager - Performance Assessment — Date

for Allen R. Whiting — 12/27/90
Director-Systems Engineering and Integration — Date

REV 1. 12/3

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25	Leon Reiter	NWTRB	703/235/4473

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PROCESS: RISK/DECIS. METHODOLOGY

1. MEETING(S) ON:
   - METHOD OF SPECIFYIN. OF MODELS/PARAMETERS/ASSU. TIONS, AND PROBABILITIES.
   - METHOD OF ENSURING PROPER INTERACTION AMONG TECHNOLOGIES
   - RULES OF APPLICATION:
     - USE OF DATA
     - CONSIDERATION OF ALTERNATIVES
   - USE OF RESULTS
2. MEETING(S) ON SPECIFIC TECHNOLOGIES.
3. MEETING(S) ON INTERACTIONS.
4. MEETING(S) ON RESULTS/SENSITIVITIES/CONCLUSIONS.

GOALS

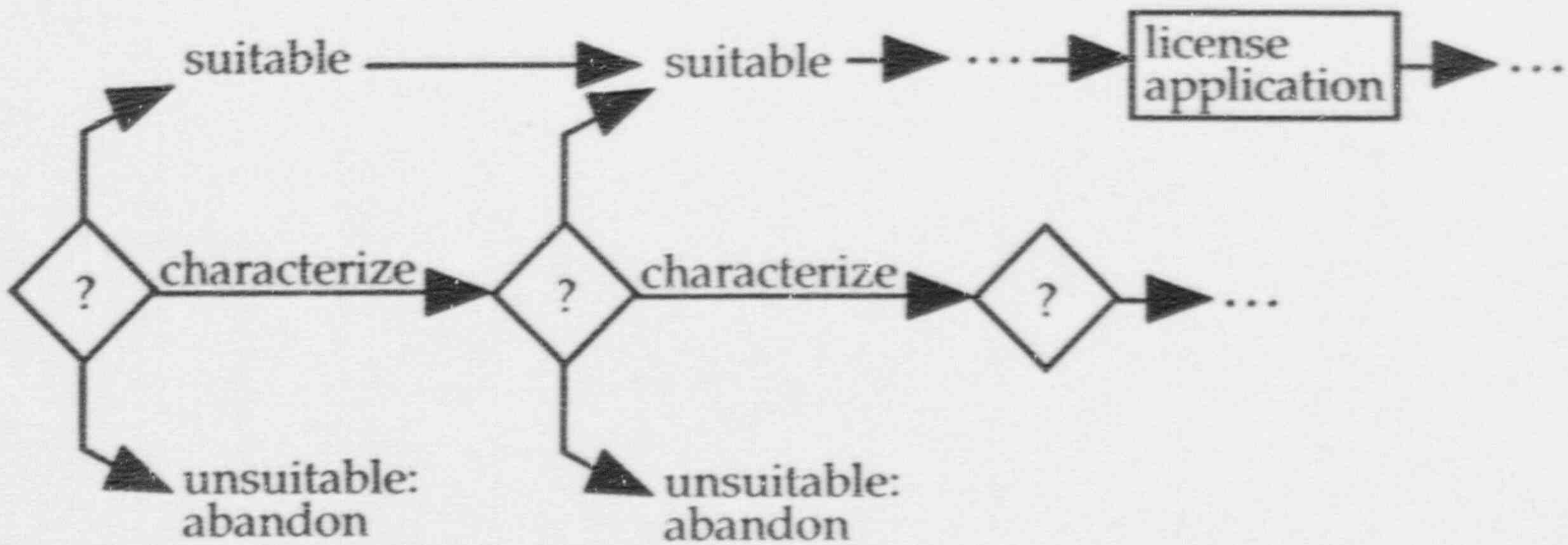
FOR AN APPLICATION OF AN EARLY SITE EVALUATION PROCESS IN THE 1990's:

1. WHAT SHOULD BE THE PROCESS?
2. WHO SHOULD BE INVOLVED?
3. WHAT SHOULD BE THE PRODUCT?
4. HOW CAN WE ENSURE WIDE ACCEPTABILITY OF THE RESULTS?

Yucca Mountain Site Suitability

An independent evaluation of strategy for evaluating site suitability

Golder Associates Inc.



- **suitability ≅ license application will succeed**
- **we will consider only technical suitability issues**

Approach

1. Performance Model(s)
2. Parameters Database
3. Activities Database

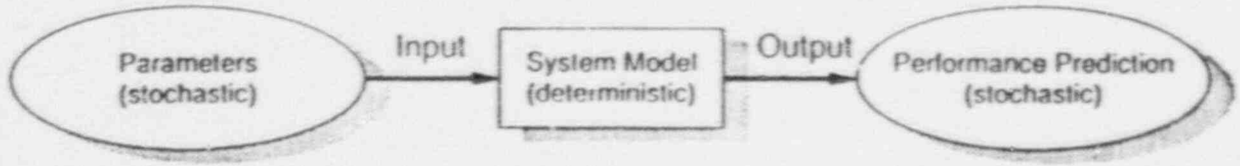
We need support from within YMPO and contractors

Structure of Performance Assessment Model

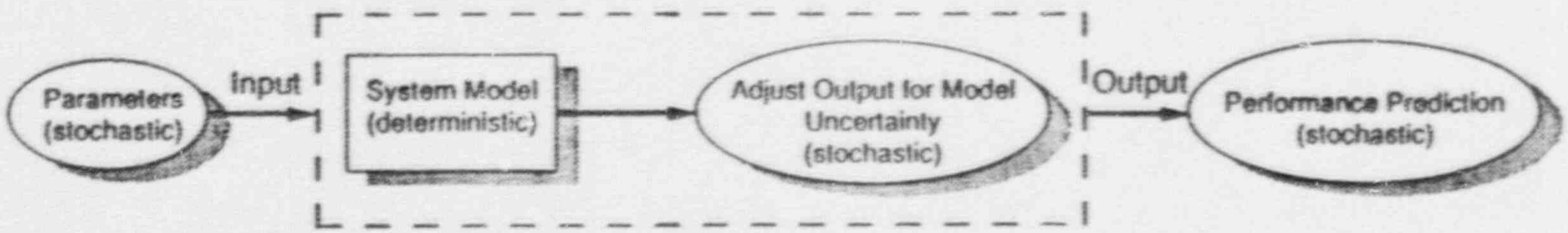
- A series of interconnected coupled component models with input/output relationships for radionuclide transfer
- "Top down" modular structure
- Uncertainly in both input parameters and the component models themselves will be explicitly included
- Many of the parameters will be represented by pdf's
- Monte Carlo method will be used to sample the distributions and simulate a large number of system realizations in order to determine probability distributions of site performance
- Need to identify:
  1) Component Models
  2) Model Parameters
  3) Uncertainties
  4) Couplings and Correlations

Component Models

- Express functional relationships between model parameters
- Simple analytical expressions → numerical sub-routines
- Models support time-dependency (time-stepping)
- Greatly simplified compared to state-of-the-art models to facilitate Monte Carlo simulation
- Components models can encapsulate sub-models
- Models will explicitly incorporate model uncertainty



a) Conventional Stochastic Model



b) Incorporation of Model Uncertainty by "Smearing" Model Output

FIGURE 2-14

INCORPORATION OF MODEL UNCERTAINTY

ARGONNE NATIONAL LABORATORY

PROJECT NO. 773-1327 DWG. NO. 22379 DATE 6/6/90 DRAWN DC

Golder Associates

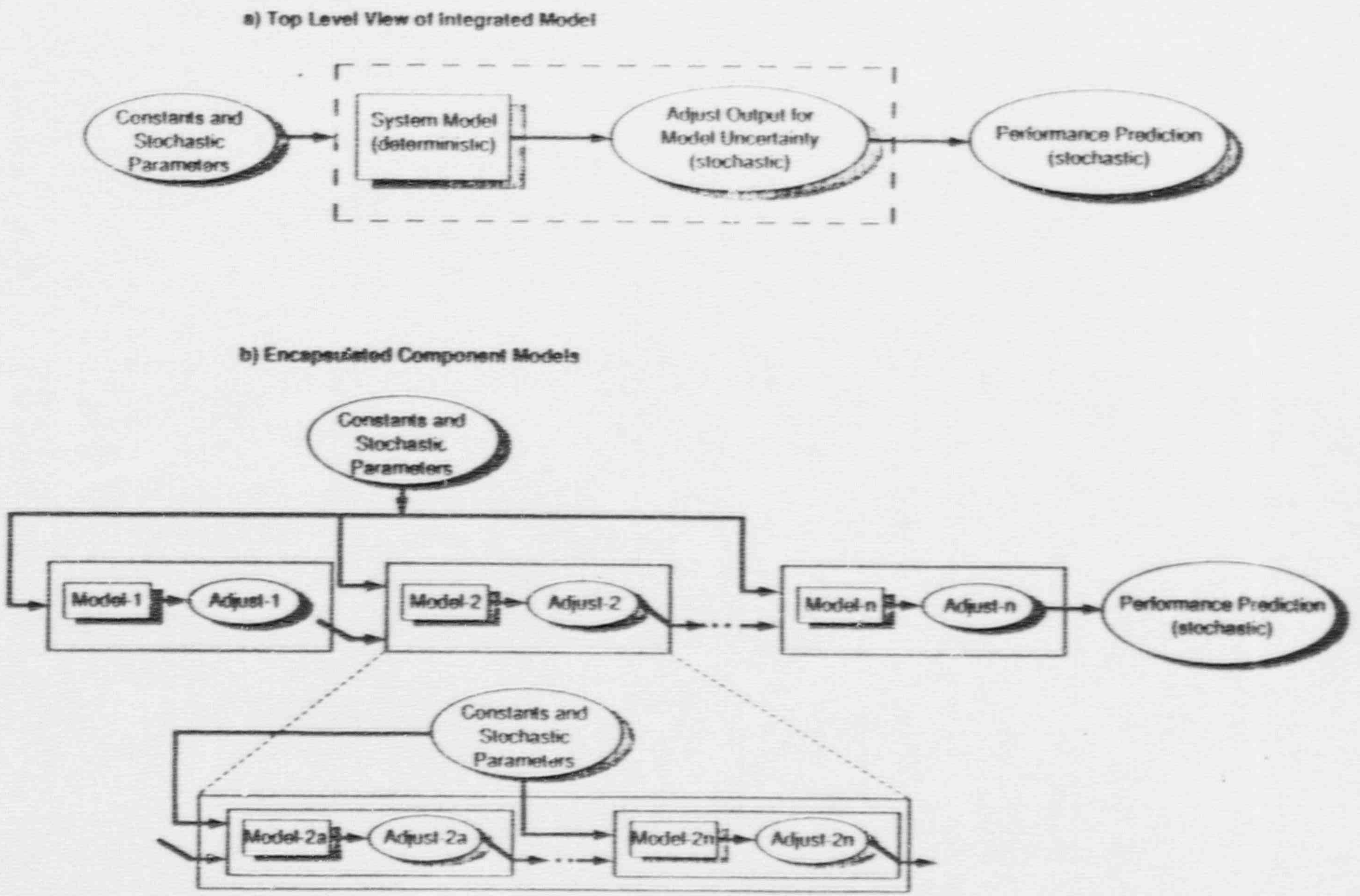


FIGURE 4

COMPONENT MODELS

Golder Associates

Model Parameters

Model parameters can be used in one of four ways:

1) To represent actual physical attributes or characteristics of the system

   e.g., temperature, porosity, infiltration rate

2) To describe the probability of a particular event or process occurring

   e.g., probability of volcanic intrusion

3) To describe the natural variabilities (spatial and temporal) and/or uncertainties (due to lack of data or understanding) in parameter types described above

   e.g., variability in hydraulic conductivity, uncertainty in hydraulic conductivity

4) To describe the uncertainties (due to simplifying assumptions or lack of understanding) in the component models themselves

   e.g., uncertainty in model producing an average linear groundwater velocity

Model Parameters

- Parameters will represent both site-specific and design features
- Parameters should be defined at a low enough level to facilitate linking the parameters directly to site characterization activities
- Overall consistency will be maintained by insuring that in a given realization a parameter has a single value for all the component models which depend on it
- Statistical correlations between sets of parameters may be incorporated
- Parameters can be time-dependent to reflect changes in state of the system
- Parameter values will be based on subjective probability assessments

Example of Component Model Formulation

Solute transport thru the saturated zone
SZ release rate = F (input rate, loss, decay, V, Error)

Task: Formulate a component model for V, the average linear transport velocity

Solute Velocity Component
Model Example

Potential forms of $V = f(K, i, R, n\ E_V)$

1) Simple analytical function

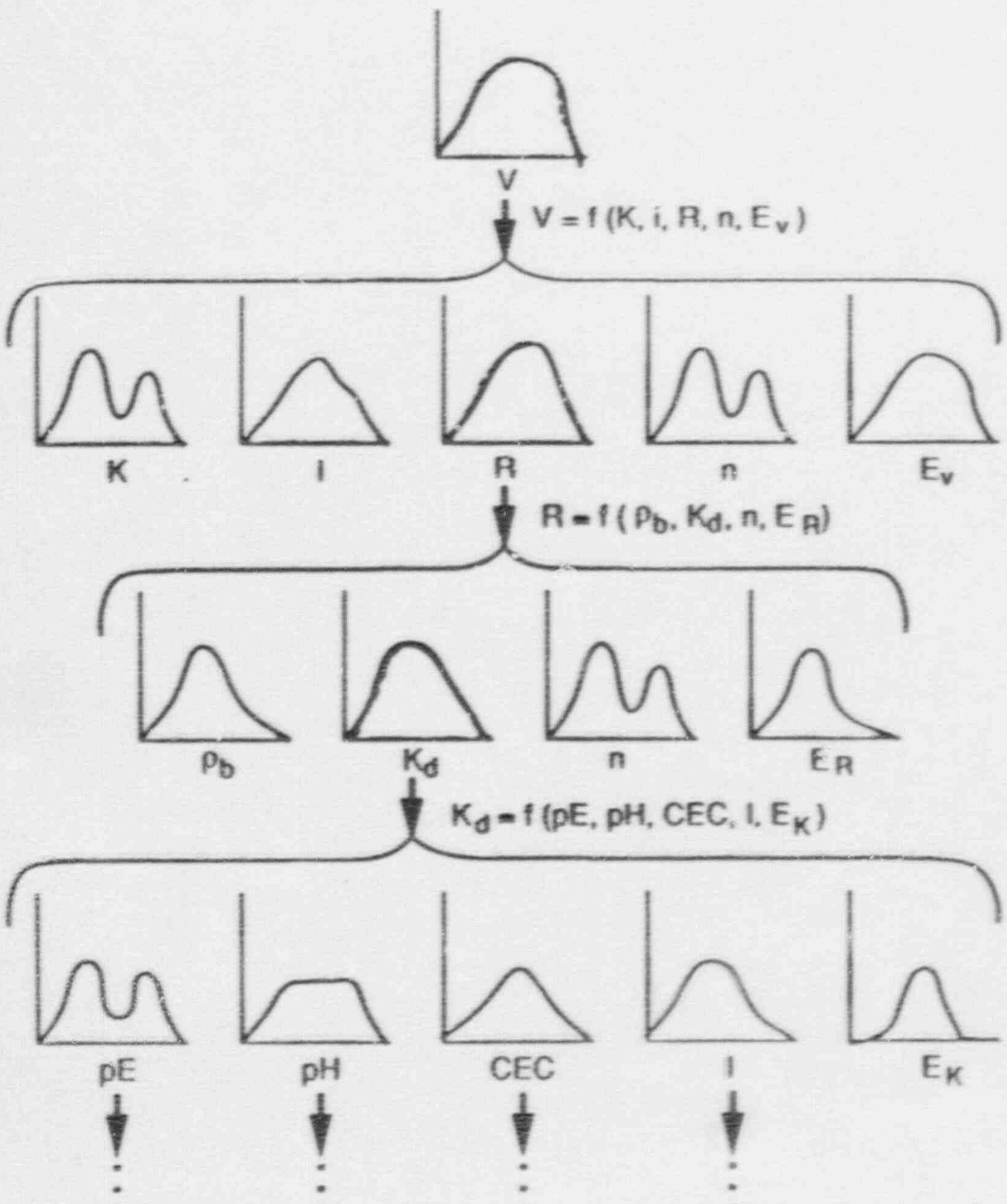
   $V = -Ki/nR * E_V$

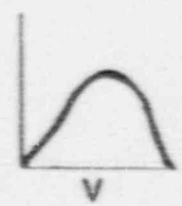
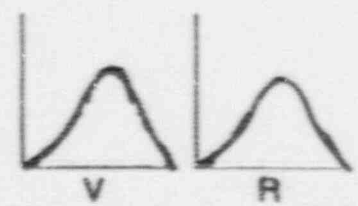
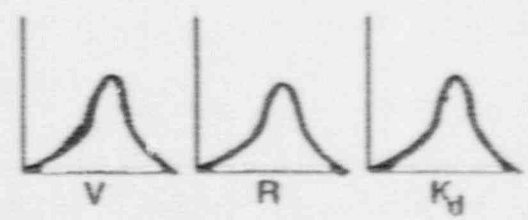
2) Simple numerical subroutine

   FUNCTION VELOCITY (K, i, n, R, E_V)

3) Tabulation of a response surface based on results of complex models

Solute Velocity Component Model Example



Parameters to be Assessed	Computed Parameter Distributions
V	
K, i, R, n, E_v	
K, i, n, ρ_b, K_d, E_R E_v	
K, i, n, ρ_b, pE, pH, CEC, I, E_K, E_R, E_v	

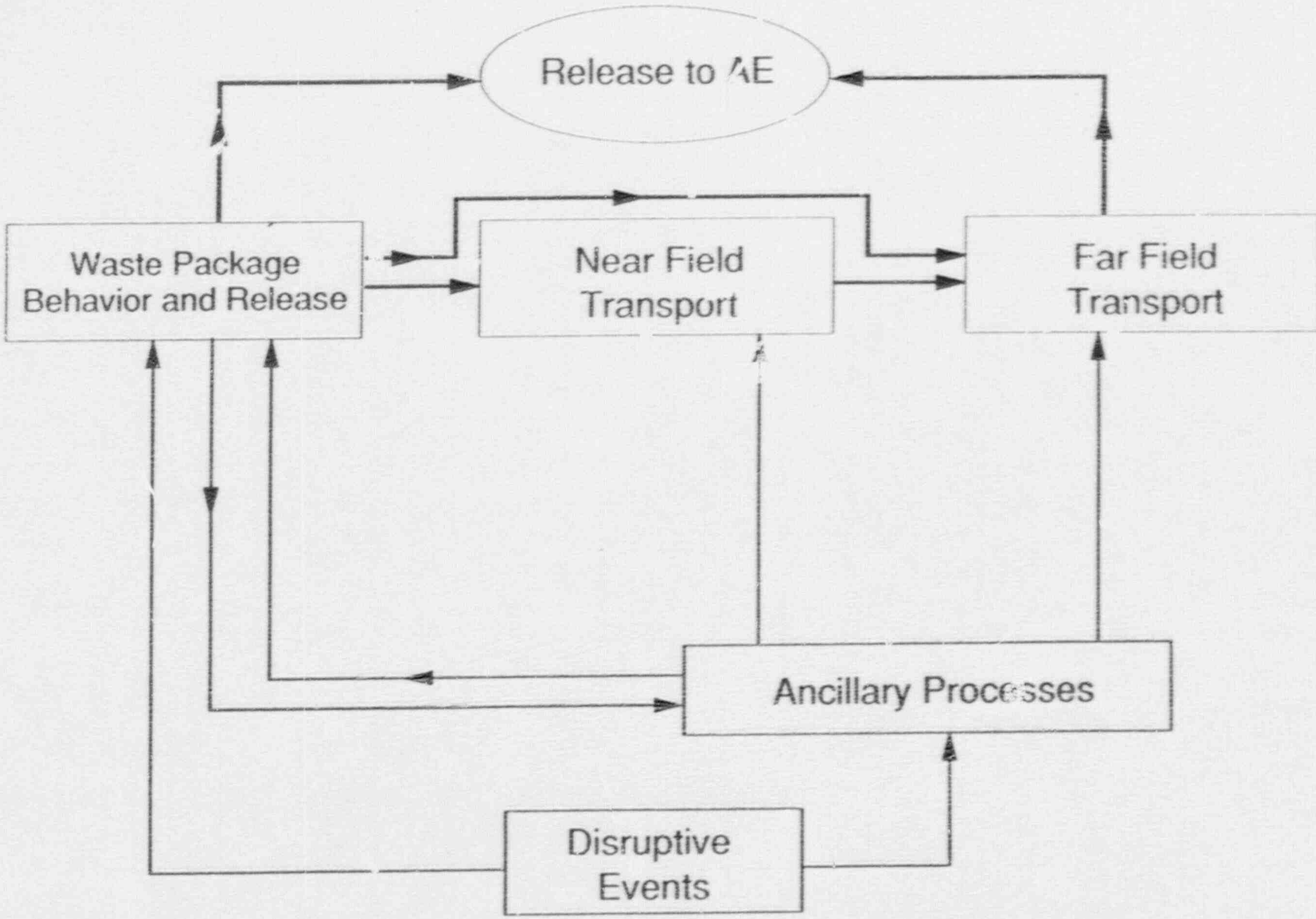
Component Models

- Three types of component models

  1) models that define and describe the behavior of the waste package

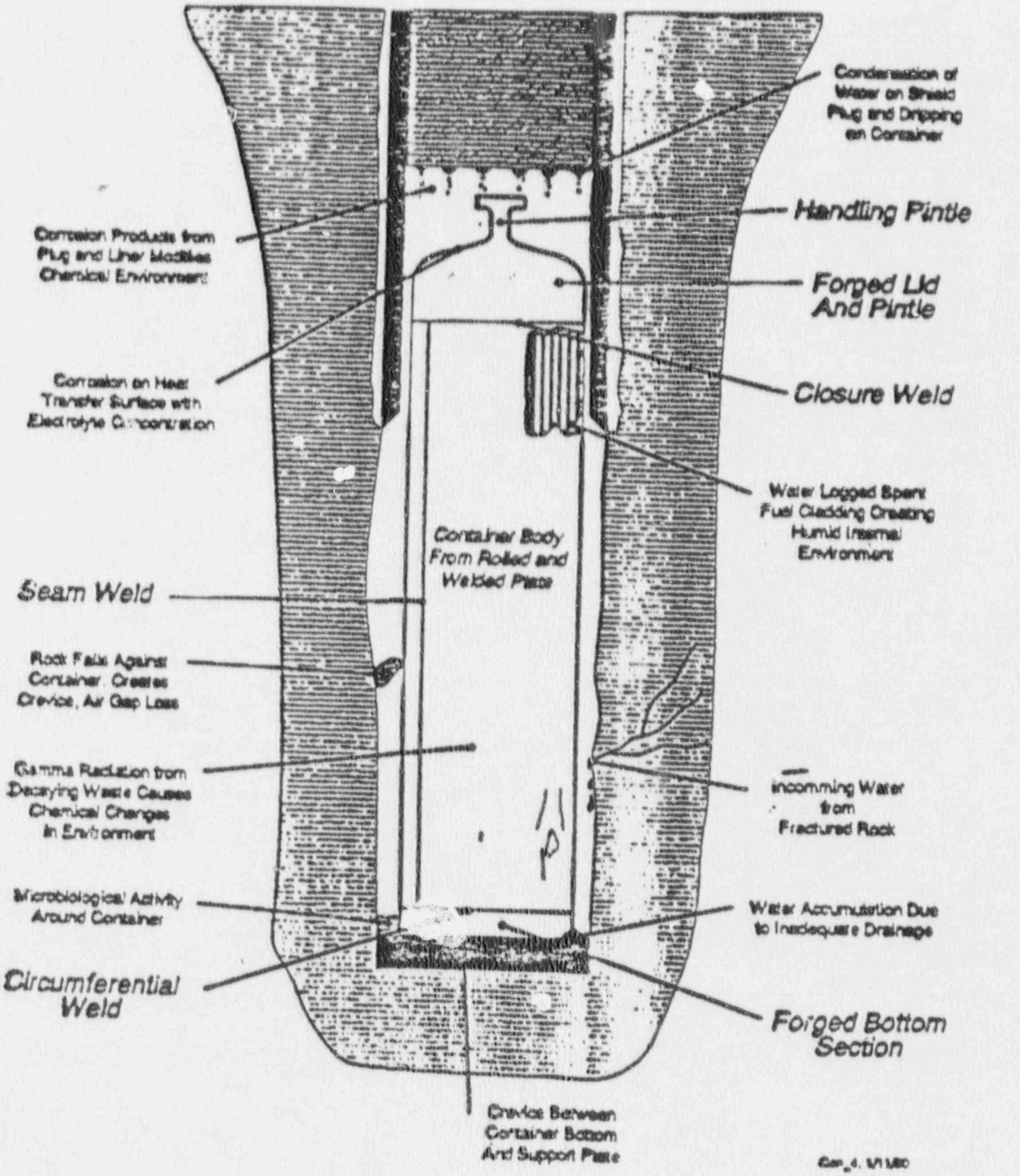
  2) models that define and describe the various pathways from the waste package to the accessible environment

  3) models which describe ancillary processes and events which can directly or indirectly affect waste package performance and/or transport pathways

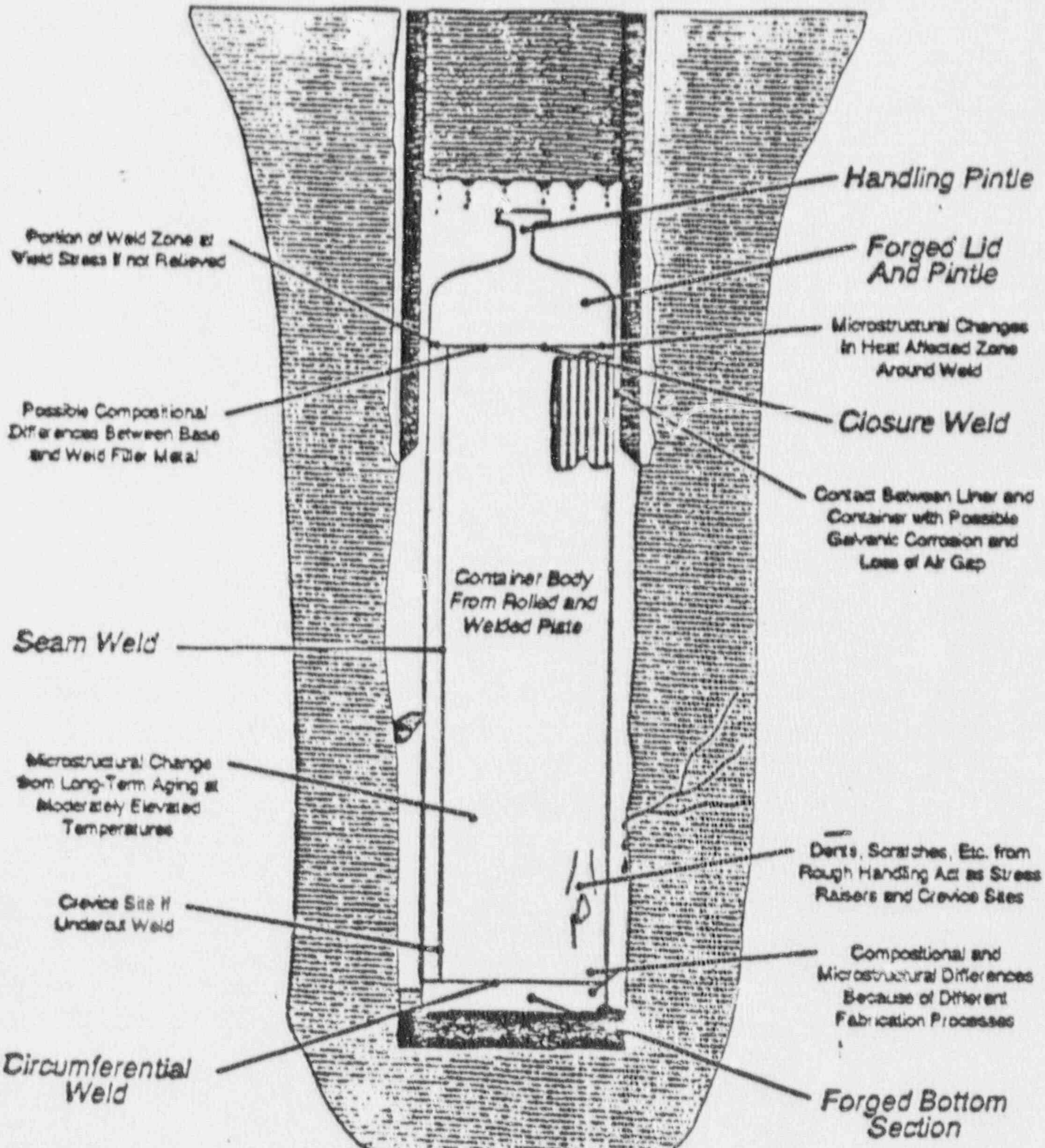


Simplified PA Model Information Flow Schematic

Container Performance Considerations
(Chemical / Environmental)



Container Performance Considerations
(Metallurgical / Mechanical)



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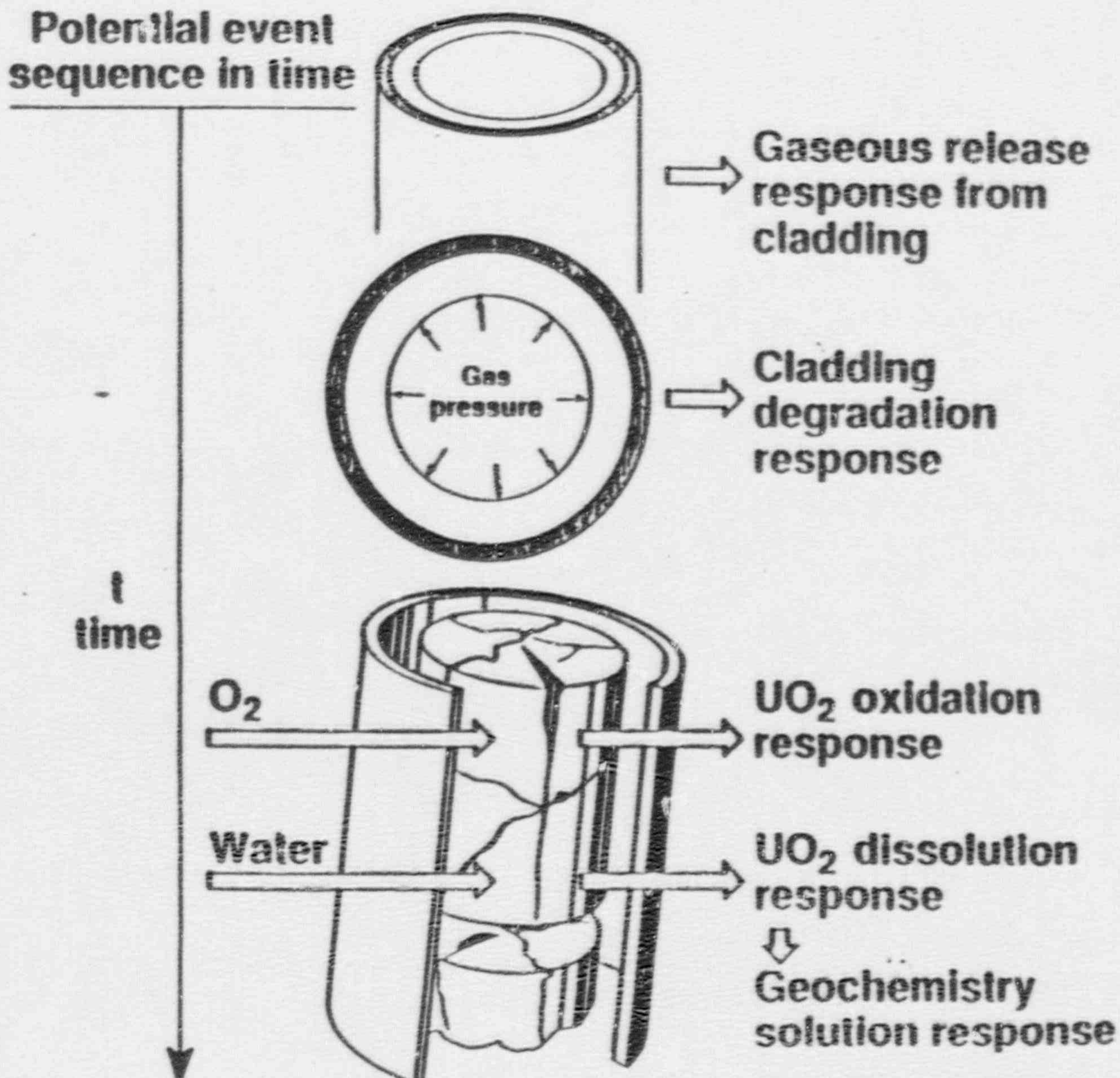
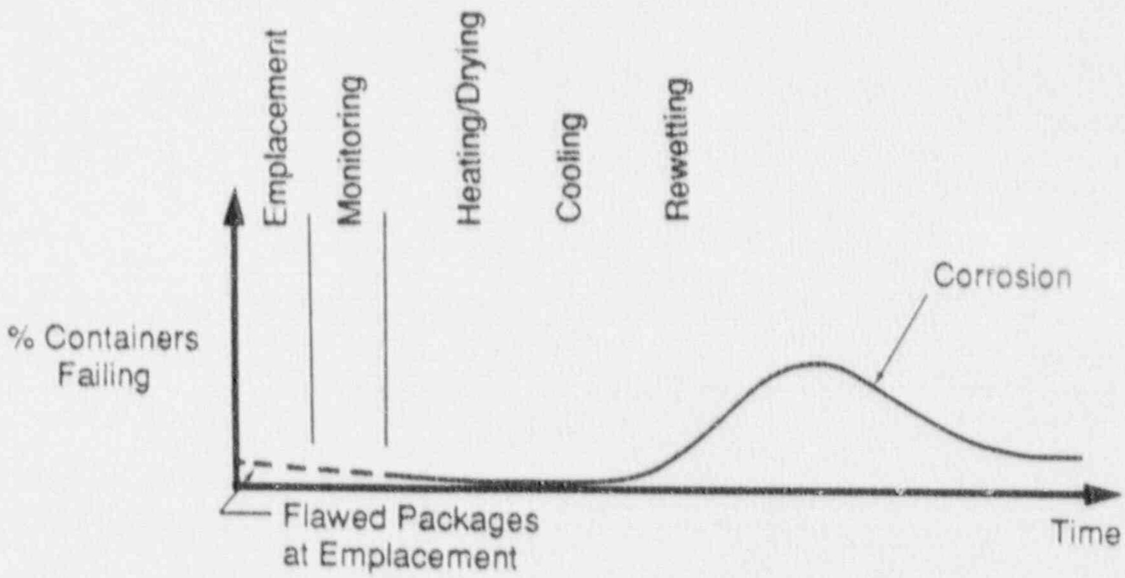
SPENT FUEL RESPONSE OVERVIEW



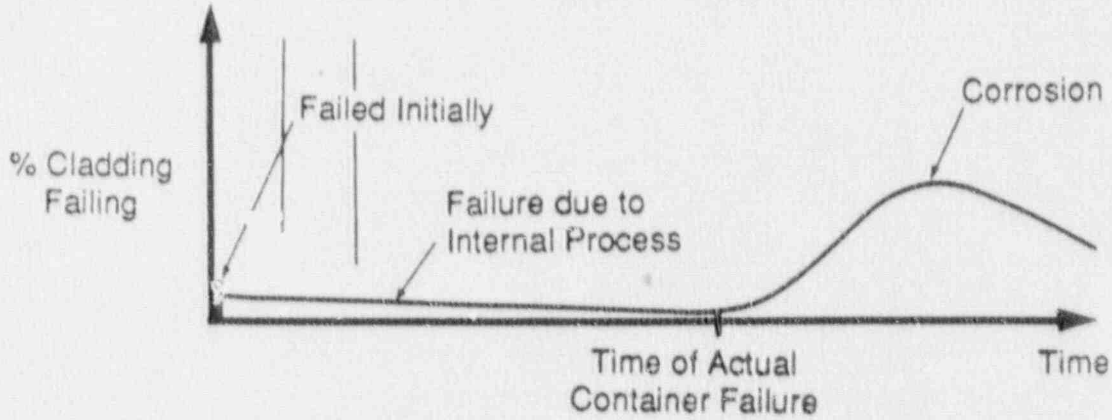
DISTRIBUTION OF CONTAINER FAILURES



Conditioning Parameters: Rewetting Time
: Local Environment Moisture
: Total Thermal Pulse
: Disruptive Events

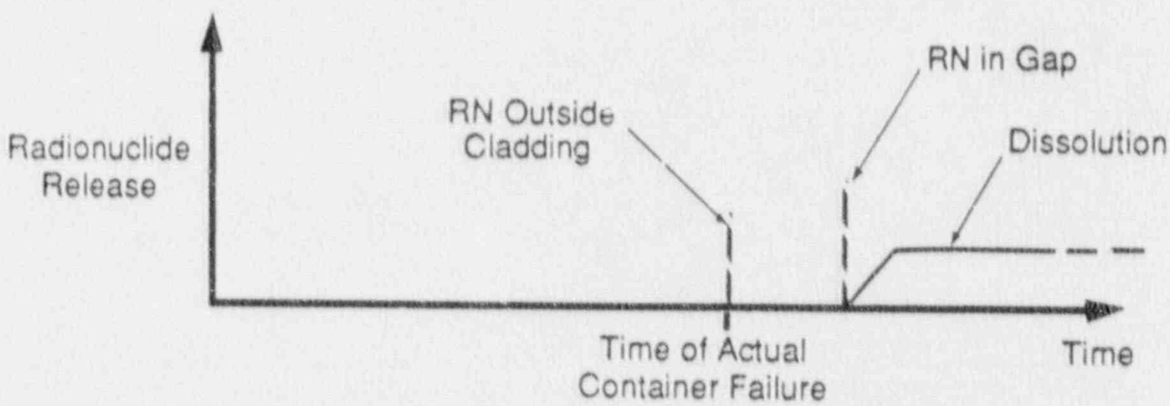
Golder Associates Inc.

DISTRIBUTION OF CLADDING FAILURES FOR A CONTAINER



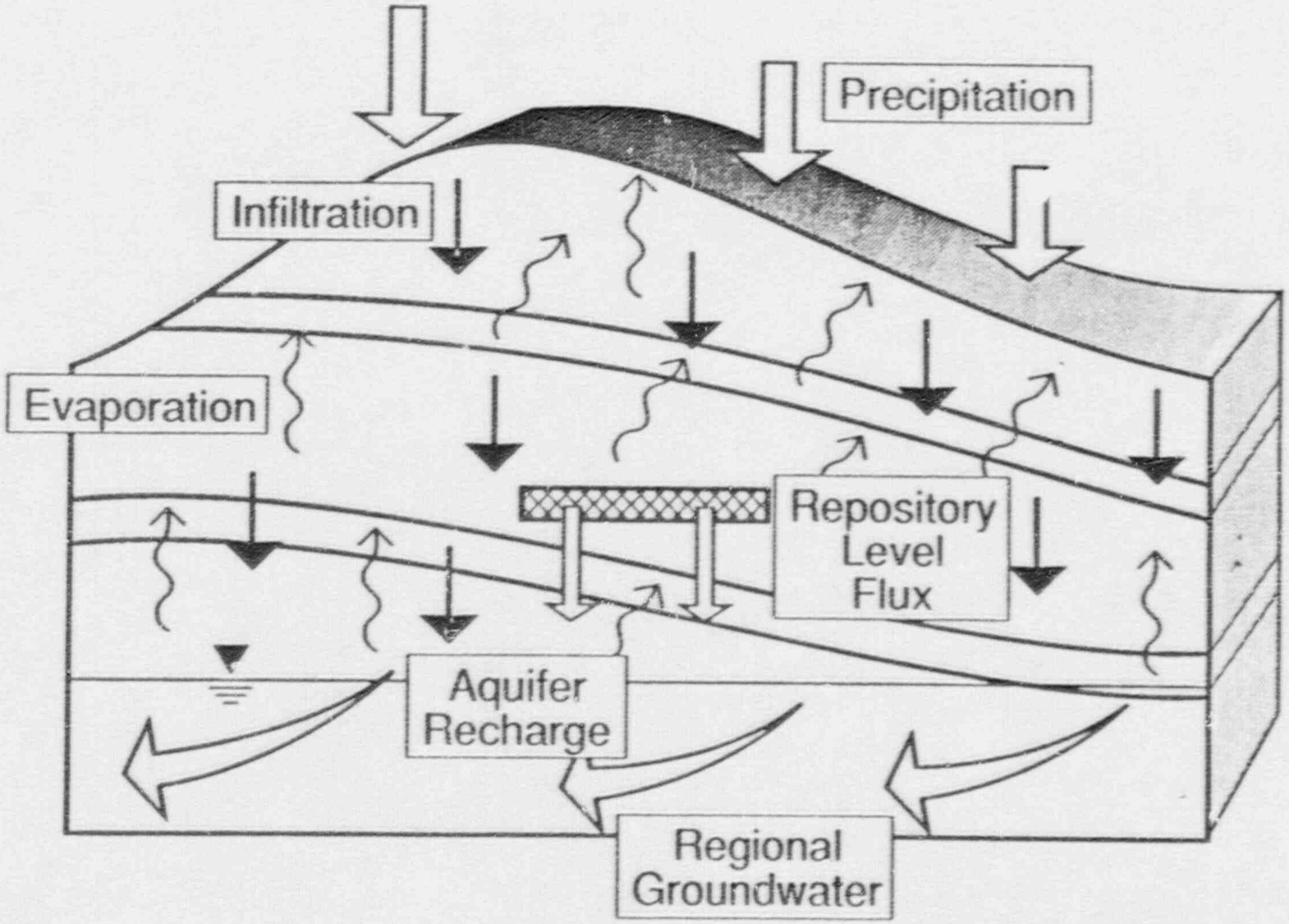
Conditioning Parameters : Local Environment Moisture
: Total Thermal Pulse
: Disruptive Events
: Time of Container Failure

RADIONUCLIDE RELEASE RATE

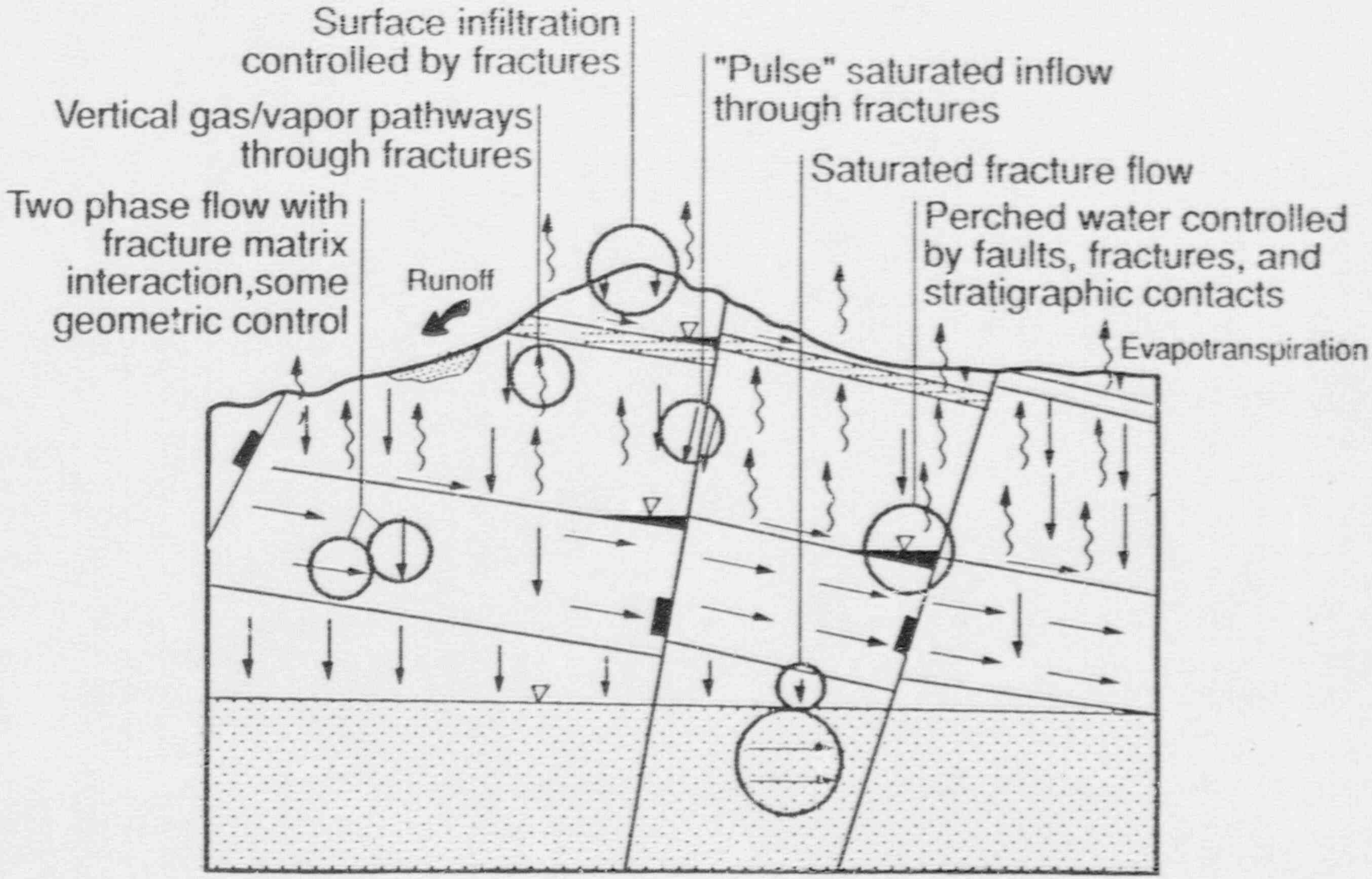


Conditioning Parameters: Specific Nuclide
Fraction in each Location
Time of Container Failure
Time of Cladding Failure
Total Inventory

Yucca Mountain Hydrologic Cycle



Fracture Flow With Heterogenous Saturation at Yucca Mountain



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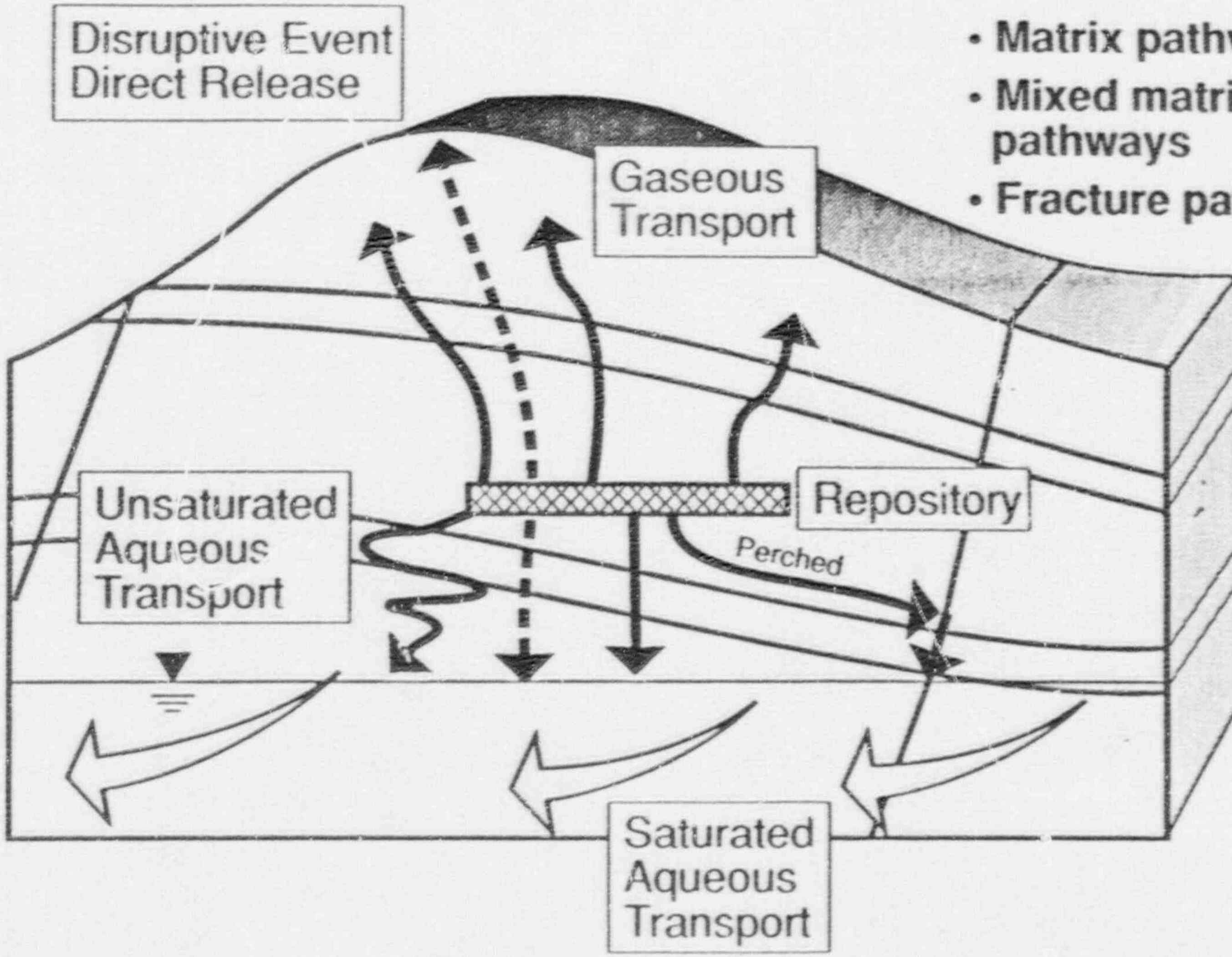
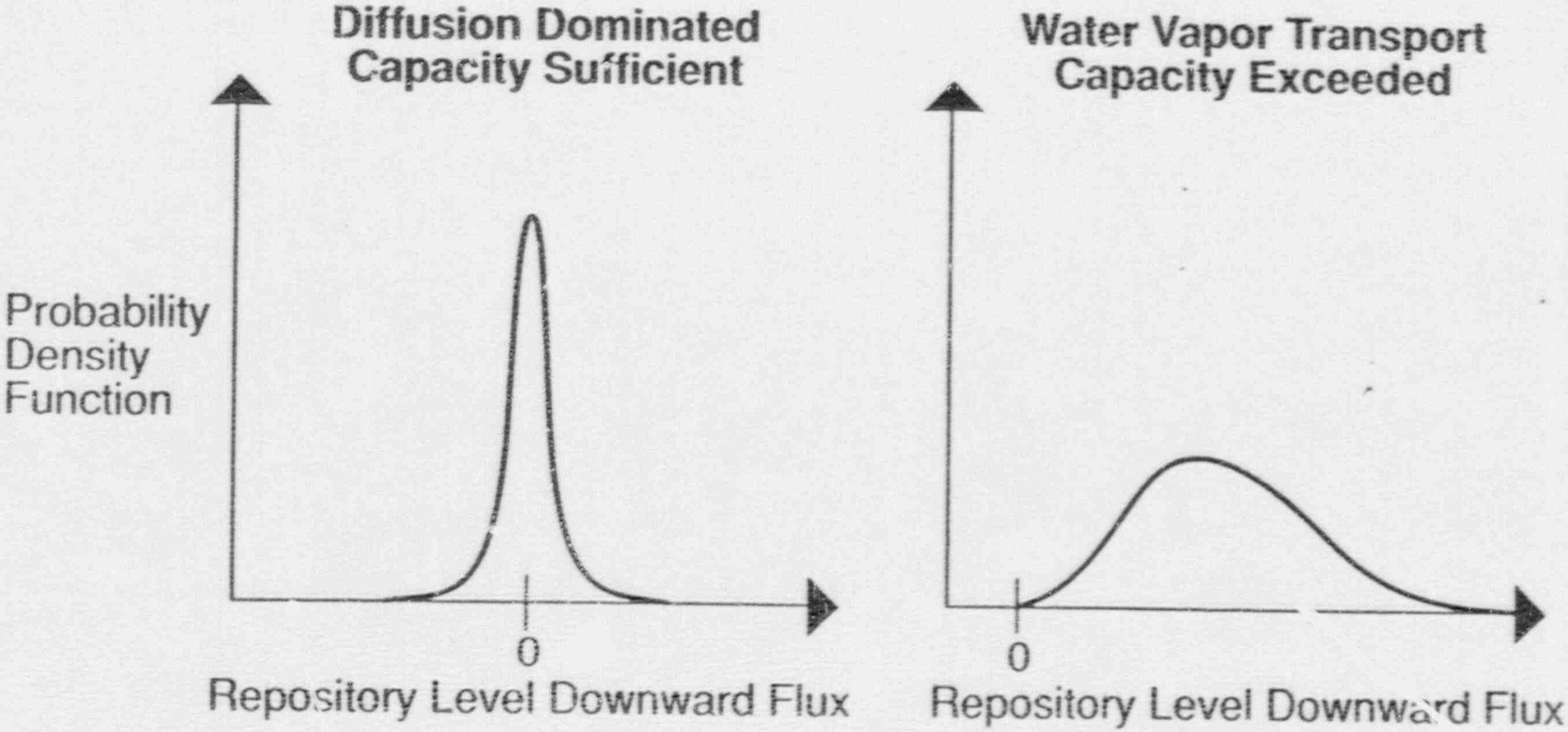
Transport Pathways Away From Repository Level



- Matrix pathways
- Mixed matrix-fracture pathways
- Fracture pathways

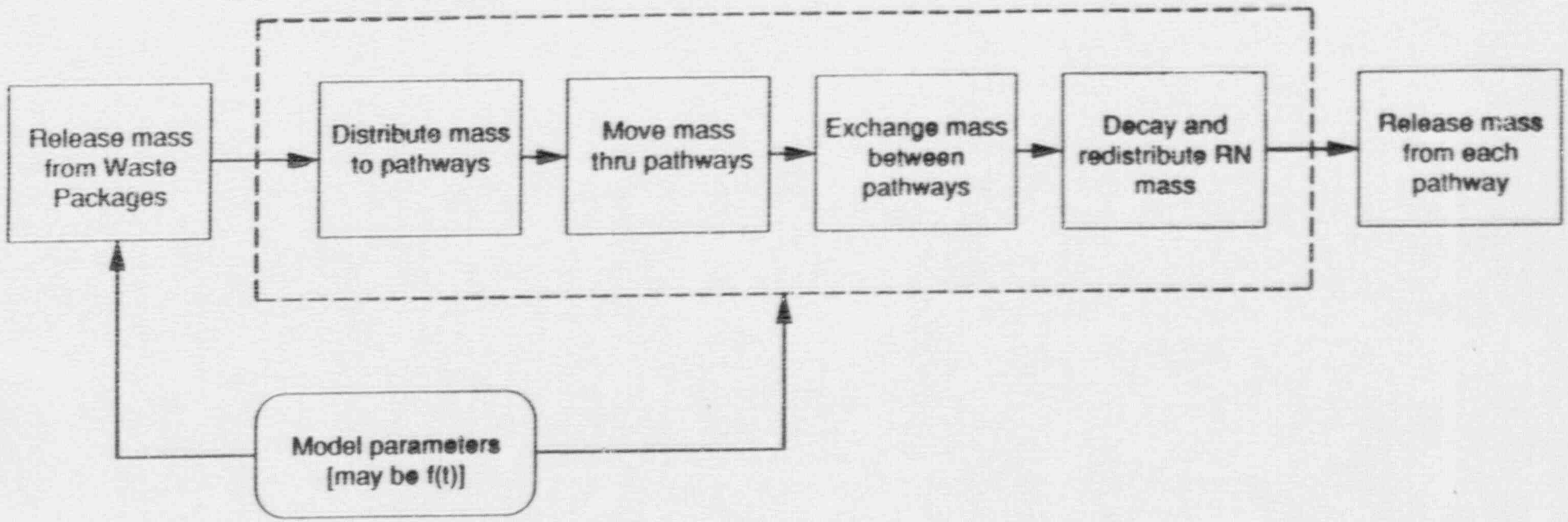
Infiltration Dependency on System Capacity



- Repository level flux may put radionuclides into transport pathways

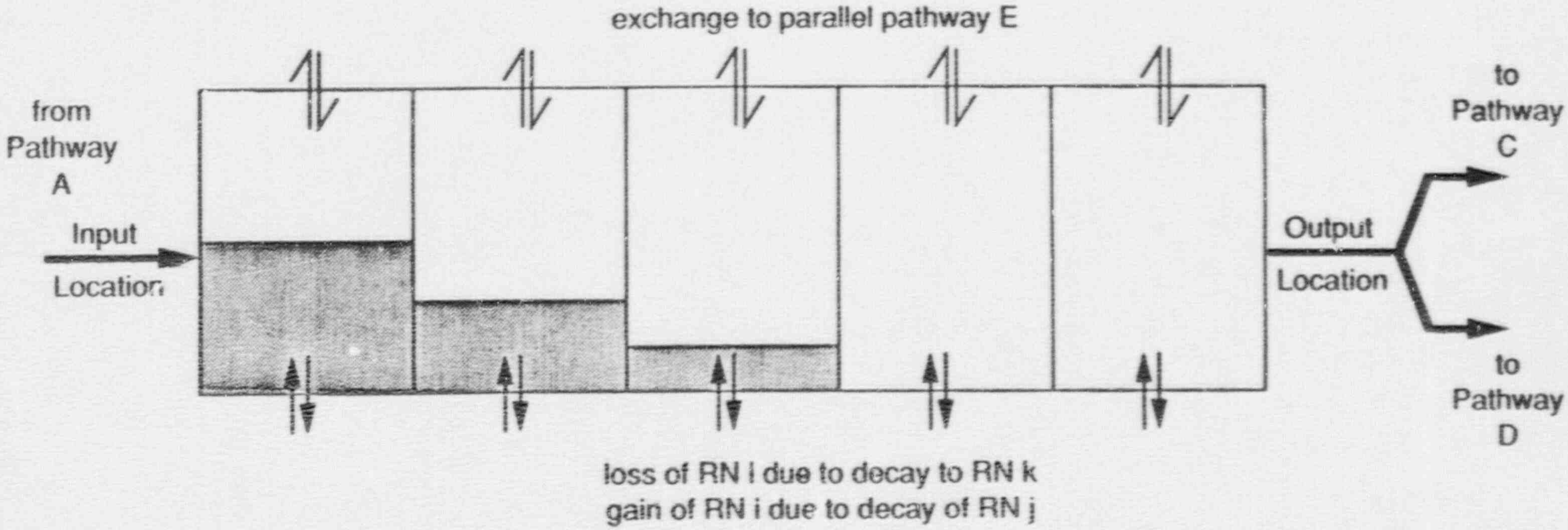
Golder Associates Inc.

Transport Pathways



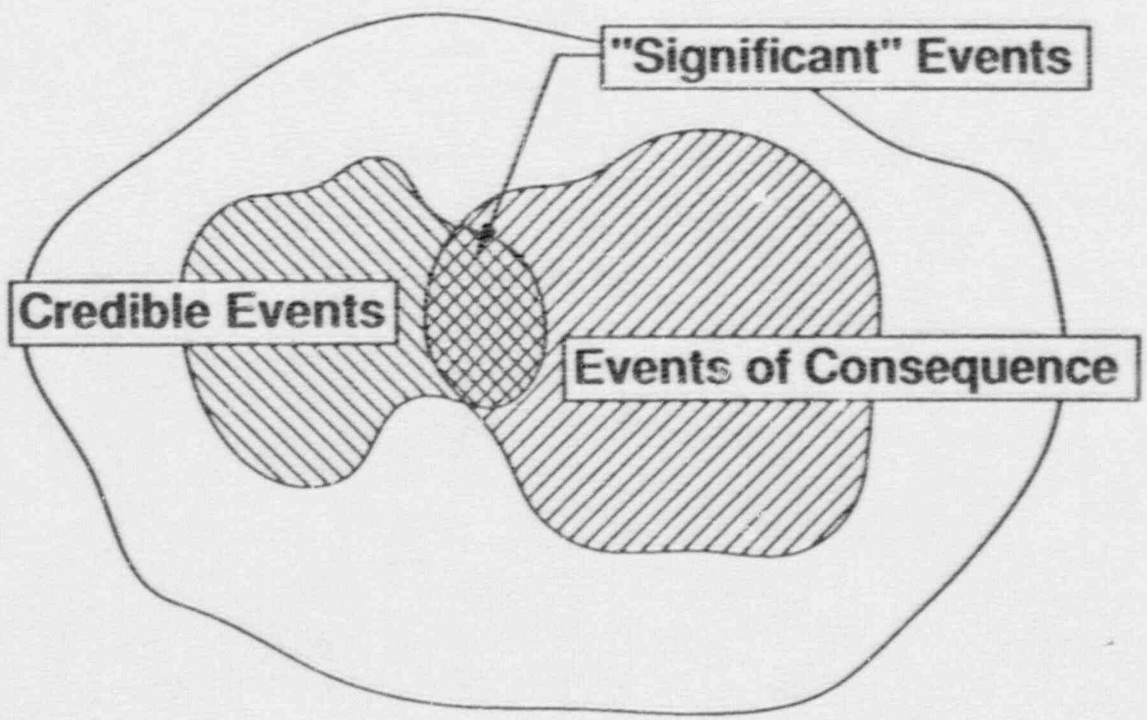
- Pathways will be temporally discretized (time-stepping)
- Pathways will be spatially discretized (allows for accurate RN decay & pathway exchange)

RN i in Pathway D

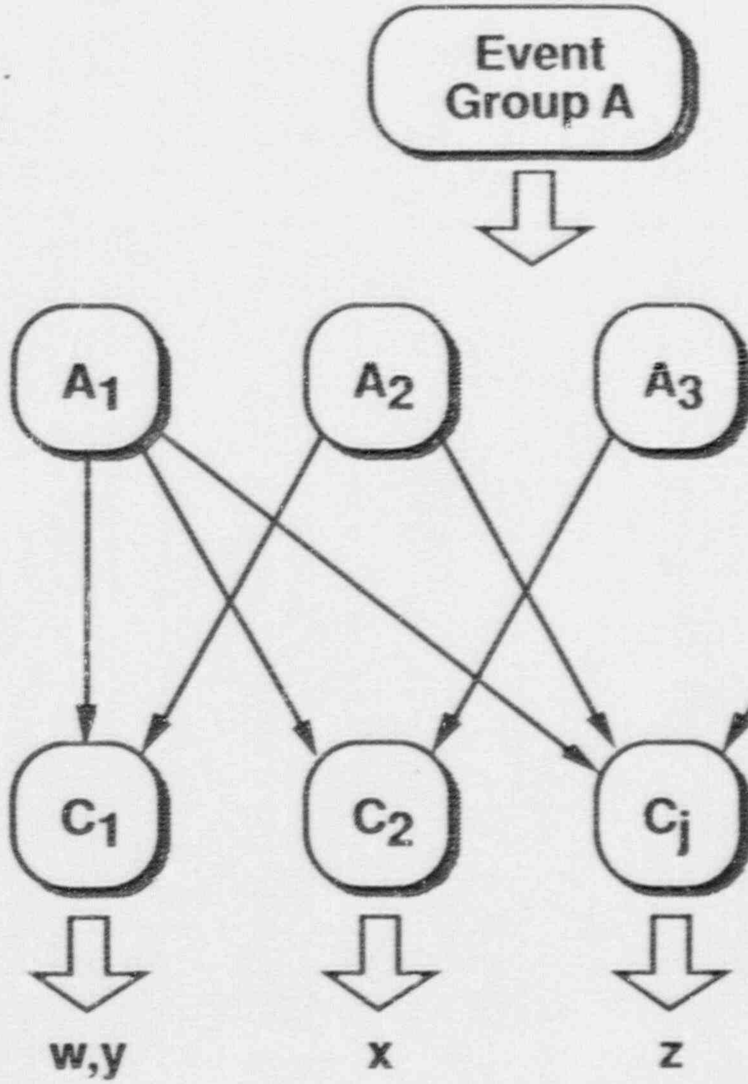


- Transfer function moves mass thru pathway (advective/dispersive)
- Exchange function exchanges mass between parallel pathways
- Decay fuction redistributes mass between nuclides

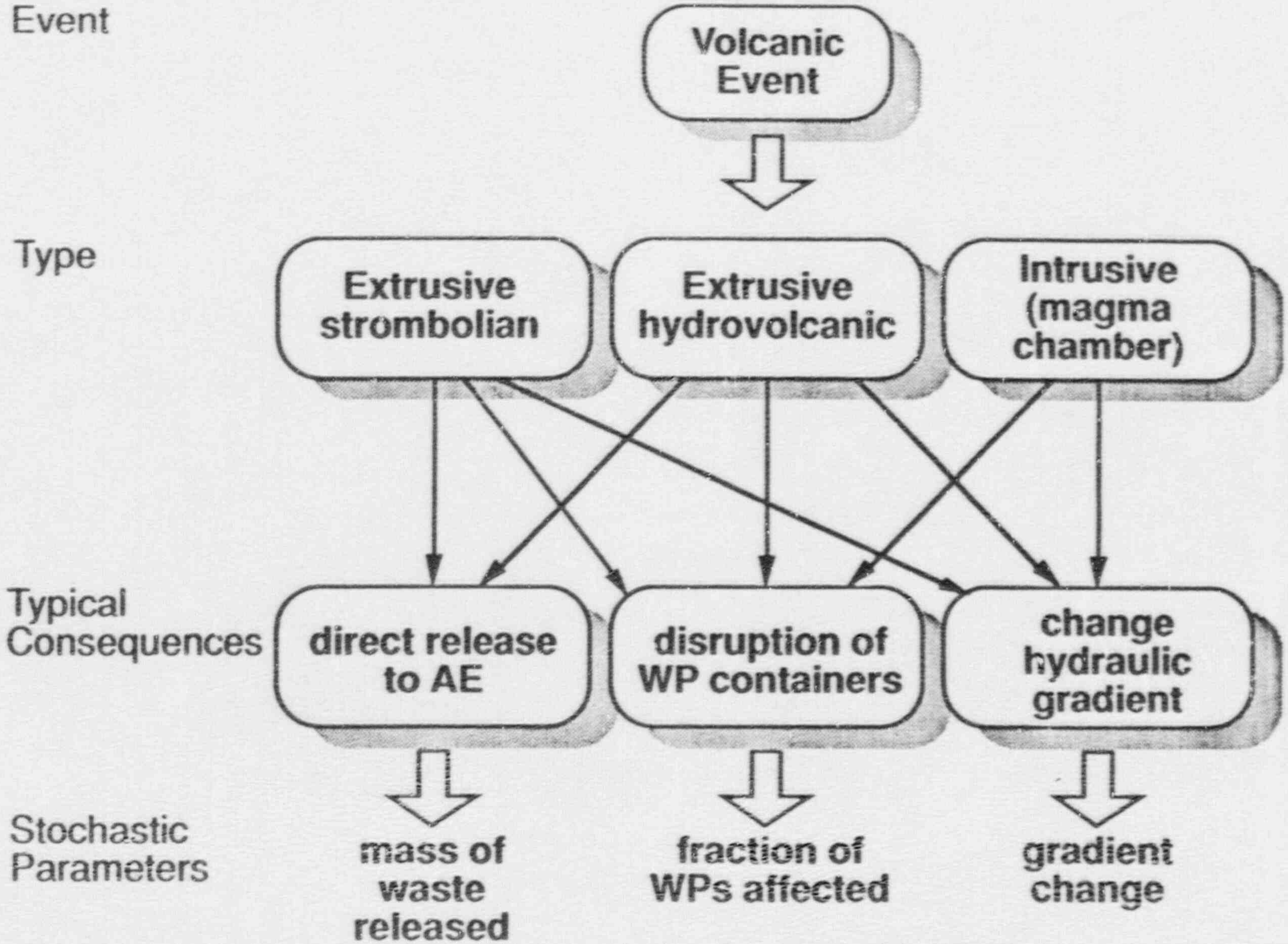
Set of All Conceivable Disruptive Events and Processes at Yucca Mountain



Model Input



occurrence of significant disruptive event	$P(A)$
identification of event type given event occurrence	$\sum_{i=1}^{n} P(A_i \mid A) \geq 1$ (correlated)
consequences of event	$P(C_j \mid A_i)$
stochastic parameters describing consequence	w,y,x,z distributions



Event
Volcanic Event
Type
Extrusive strombolian
Extrusive hydrovolcanic
Intrusive (magma chamber)
Typical Consequences
direct release to AE
disruption of WP containers
change hydraulic gradient
Stochastic Parameters
mass of waste released
fraction of WPs affected
gradient change

Preliminary List of Disruptive Events

- **Volcanism**
  - extrusive strombolian
  - extrusive hydrovolcanic
  - intrusive (magma chamber)
- **Faulting**
  - primary faulting within repository
  - secondary faulting within repository
  - faulting outside repository
  - detachment
- **Climate**
  - precipitation change
  - evapotranspiration change
- **Human Intrusion**
  - drilling
  - resource mining
  - irrigation/flooding

Preliminary List of Disruptive Event Consequences

- Local disruption of cannisters
- Spalling at cannisters
- Water table change
- Change in infiltration rate
- Change in hydraulic gradient
- Direct release to AE or SZ
- Physical displacement of some waste

Repository Development

Phased Development of Repository

1. Early site characterization/design
   (for suitability determination)

2. Final site characterization/design
   (for license application)

3. Construction

4. Operations

5. Closure

Decisions at Each Development Phase re: Whether and How to Proceed

- External (NRC regulatory, political)
  allow further development?

- Internal (DOE management)
  wise investment to proceed?

  best program for phase (considering uncertainties and contingencies)?

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Repository Development

Alternatives

- To further development
  (within Federal Waste Disposal System)
- For programs at each phase
  (including contingencies)

Consequences

- Successful development or not at
  Yucca Mountain
- Overall project cost through closure
- Time to initial waste receipt
- Health and safety impacts
- Others

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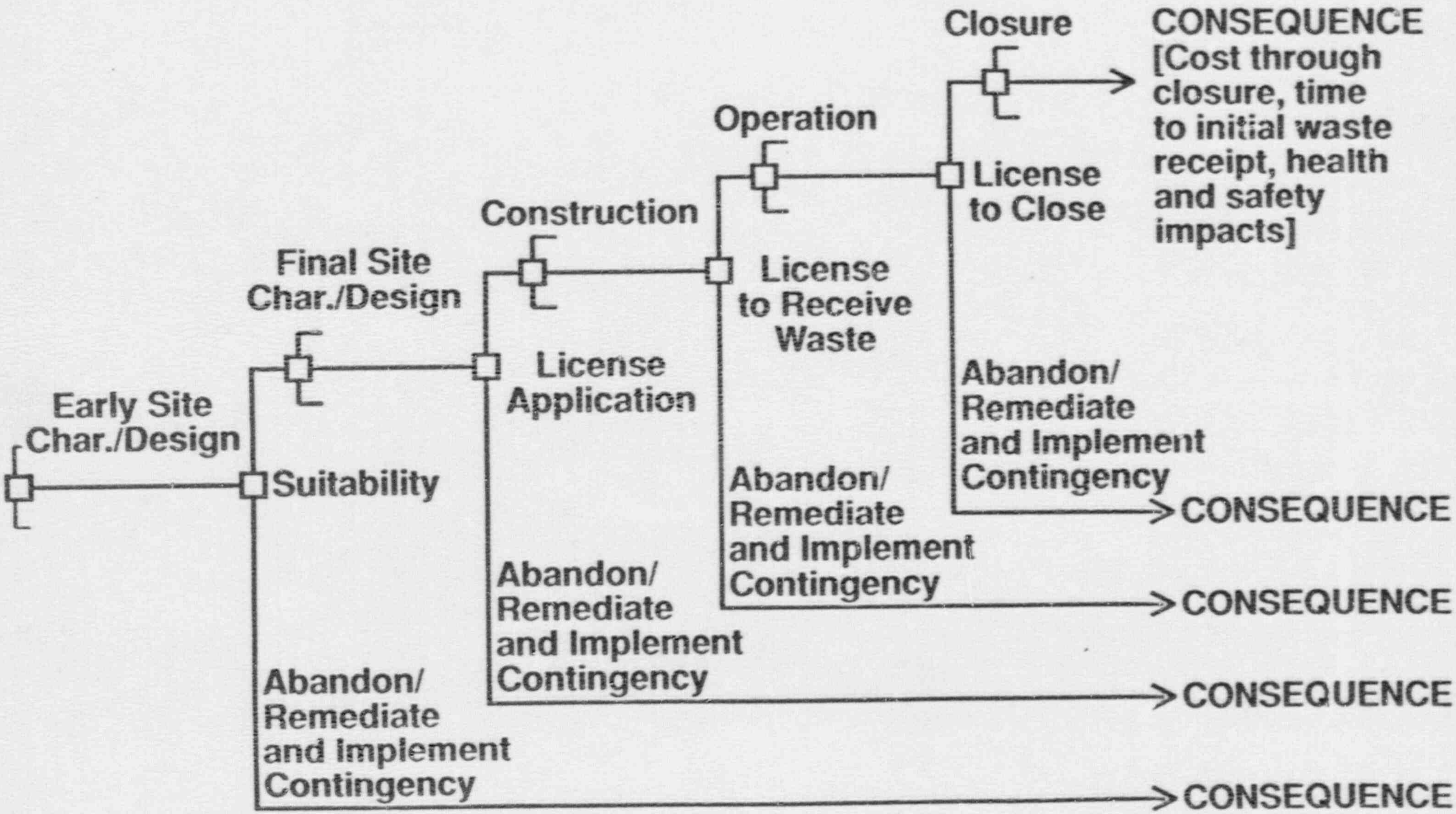
Phased Repository Development Process



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Role of Performance Assessment

Regulatory Compliance

- Predict performance based on available information for comparison with regulations.

Investment Decision

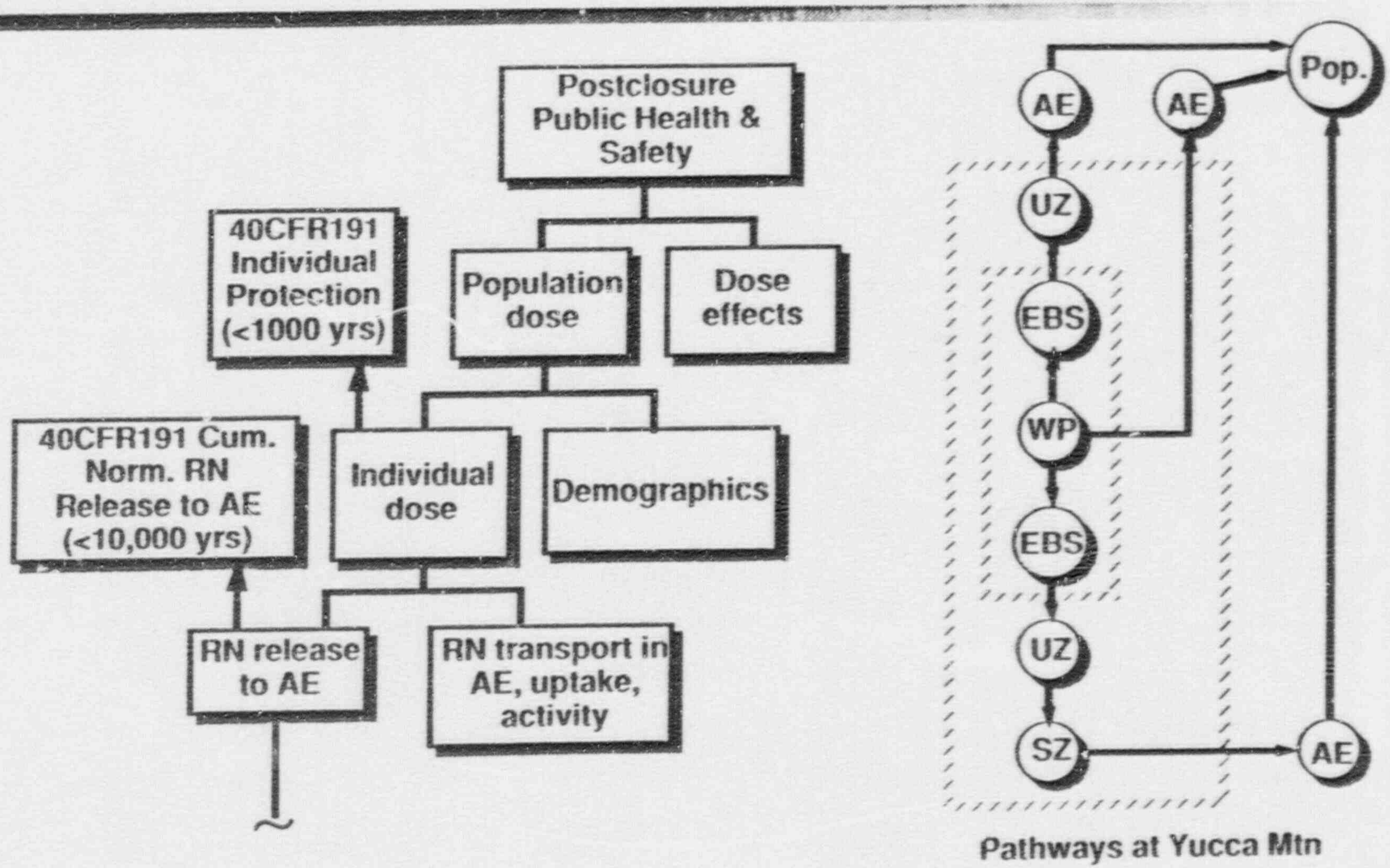
- Predict ability to demonstrate compliance in future based on additional information to be obtained ("learning") and on available design flexibility/contingencies ("correcting")
- Evaluate and compare alternative programs in terms of their relevant consequences (e.g., overall cost through closure, schedule through intial waste receipt, long-term health and safety impacts), which in turn will be a function of their ability to demonstrate compliance.

Regulatory Postclosure Performance Standards

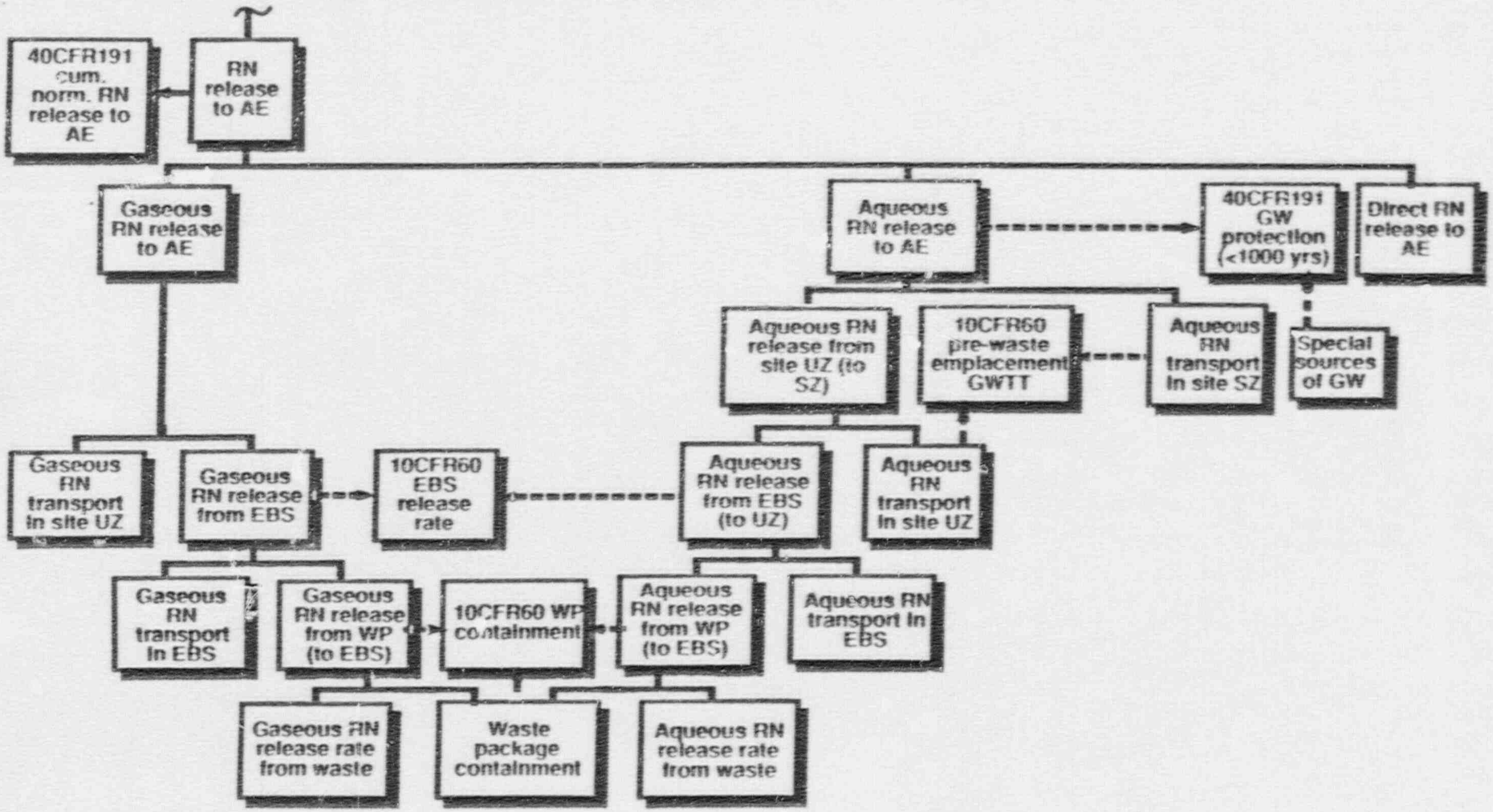
- **Criteria**
  - 40CFR191
    - P[Cumulative Normalized RN Release to AE (<10,000 yrs)]
    - Individual Protection (<1000 yrs)
    - Groundwater Protection (<1000 yrs)
  - 10CFR60
    - Pre-waste Emplacement Groundwater Travel Time
    - EBS Release Rate
    - WP Containment
- **Features of Criteria**
  - Hierarchial
  - Inappropriate

  } ⇒ Unnecessary System Constraints

Hierarchy of Regulatory Postclosure Performance Standards



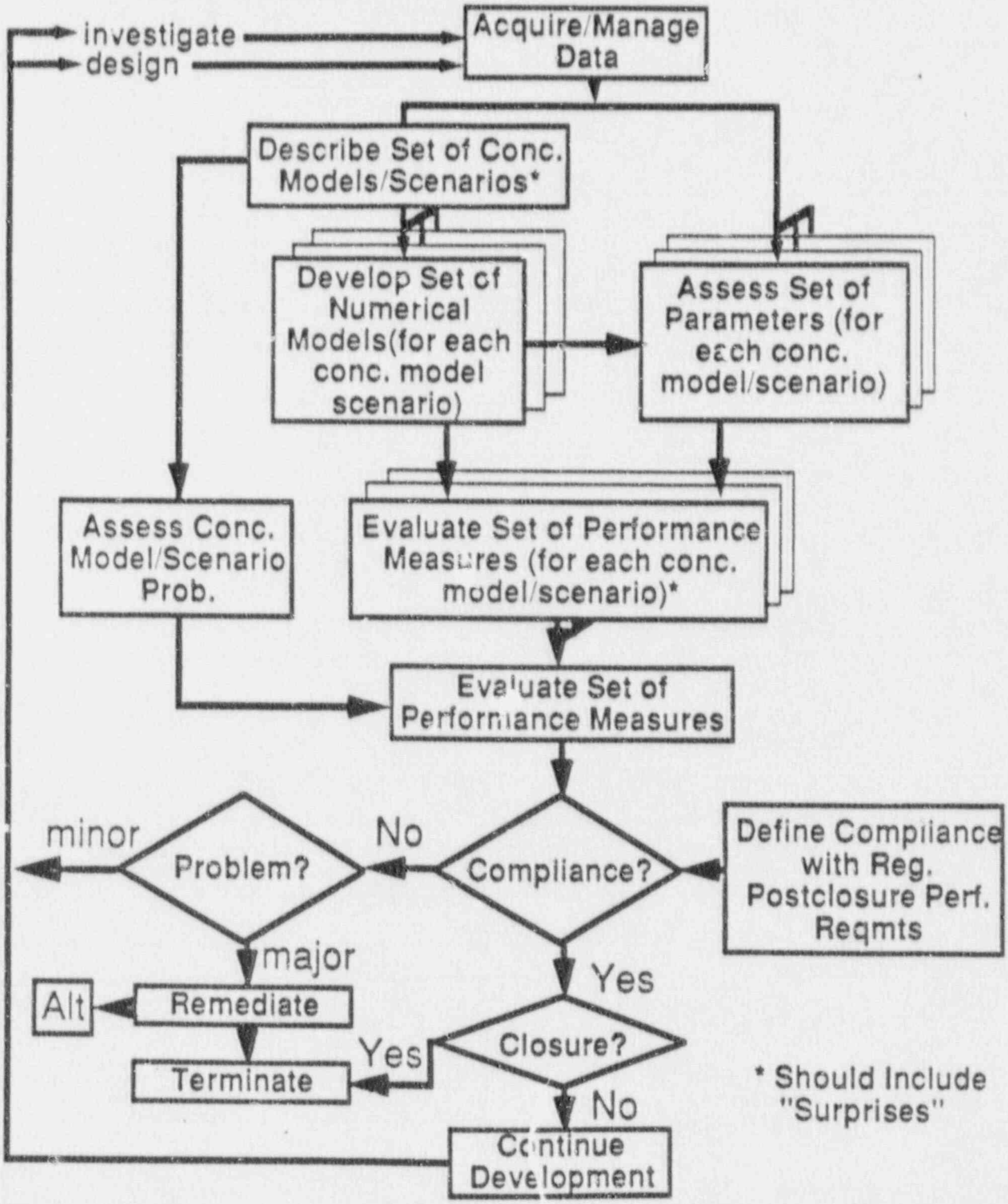
Hierarchy of Regulatory Postclosure Performance Standards (cont.)



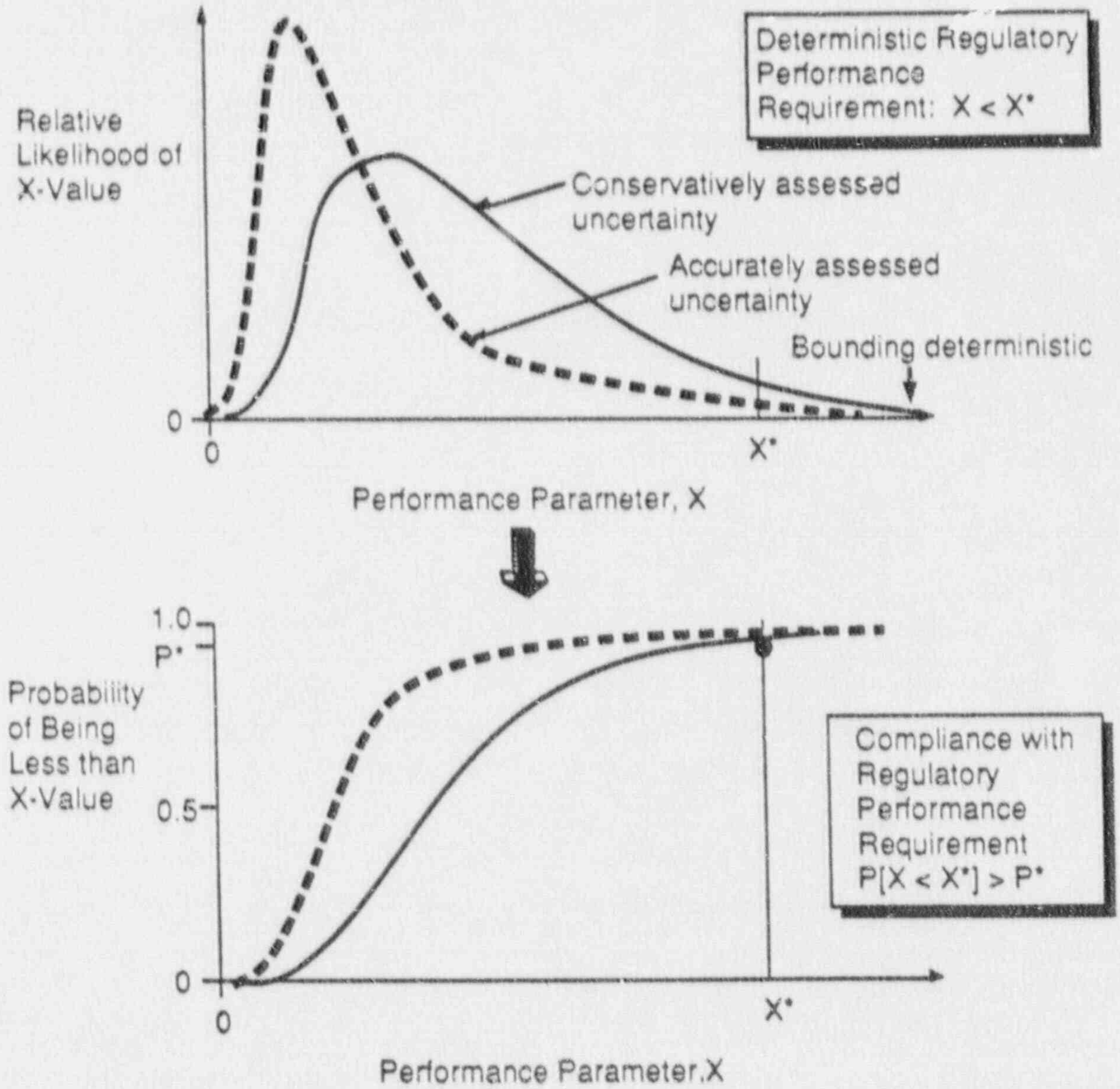
Demonstration of Compliance

- Must "demonstrate" that "actual" performance will "satisfy" criteria
- Significant uncertainty will always exist in what actual performance will be
- Show that probability of actual performance being acceptable is sufficiently high
- Through performance assessment, either
  - "bound" performance
  - assess likely performance and its uncertainty

Determination of Compliance by PA



Definition of Compliance



e.g. X = Engineered System Fractional Annual Release Rate

$X^* = 10^{-5}$

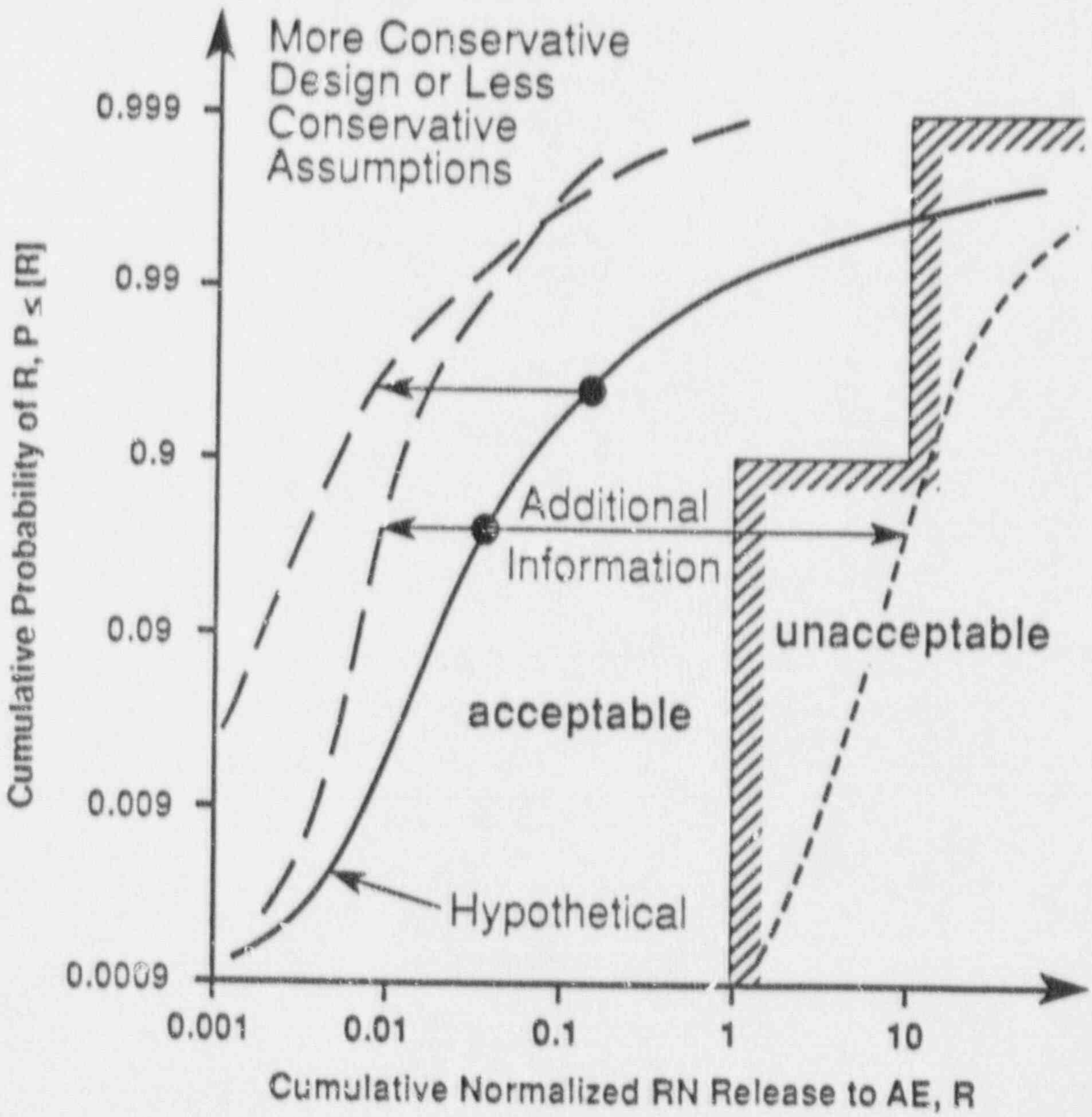
P^* = ? ("reasonable assurance")

e.g. X = Cum. Norm. RN Release to AE

$X^* = 1$ $X^* = 10$

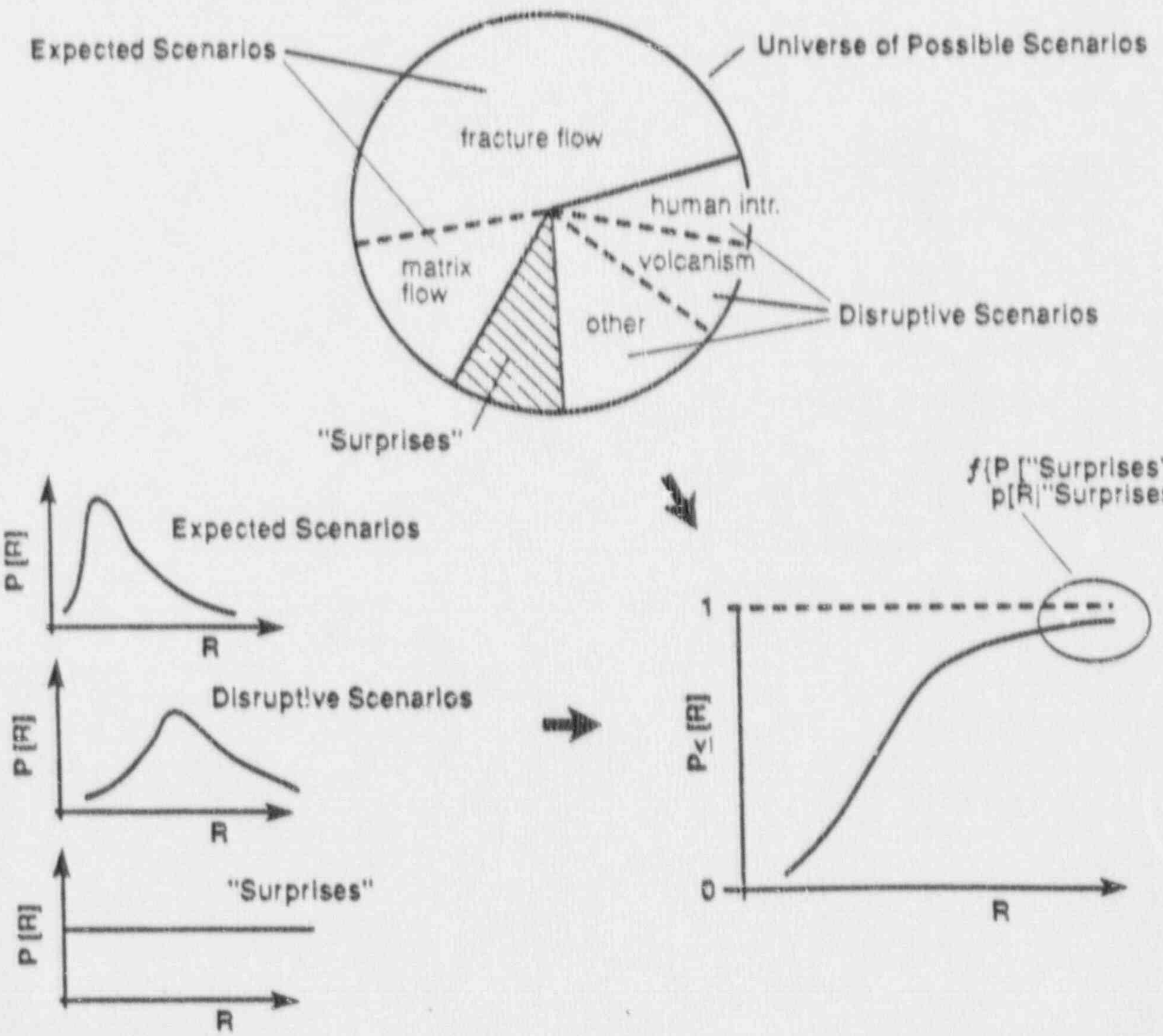
$P^* = 0.90$ $P^* = 0.999$

Definition of Compliance (40 CFR 191)



"Surprises"

- Extreme tail of distribution dominated by possible "surprises"
- Probability of "surprises" initially high, decreasing with time as performance is monitored



DOE Management Investment Decision

Project Success

- Defined as proceeding all the way through closure at Yucca Moutain.

- Requires a decision to proceed at *all* decision points, which in turn requires adequate demonstration of compliance with all regulatory requirements (performance and nonperformance) and public/political acceptability at *all* decision points.

- Probability of success can be adequately approximated by the probability of demonstrating compliance with EPA 40CFR191 *at closure.*

Investment Decision

- The decision to proceed at each phase is based on the probability of success at that point:

  if P[S] is very high, then the site is clearly suitable for further development

  if P[S] is low, then the site is clearly not suitable for further development

  if P[S] is marginally high, then additional work may be required in order to refine P[S] and determine suitability

  The threshold for proceeding or not at each phase is a function of the consequences of "failure", where failure is defined as subsequently *not* being able to proceed through closure at Yucca Mountain.

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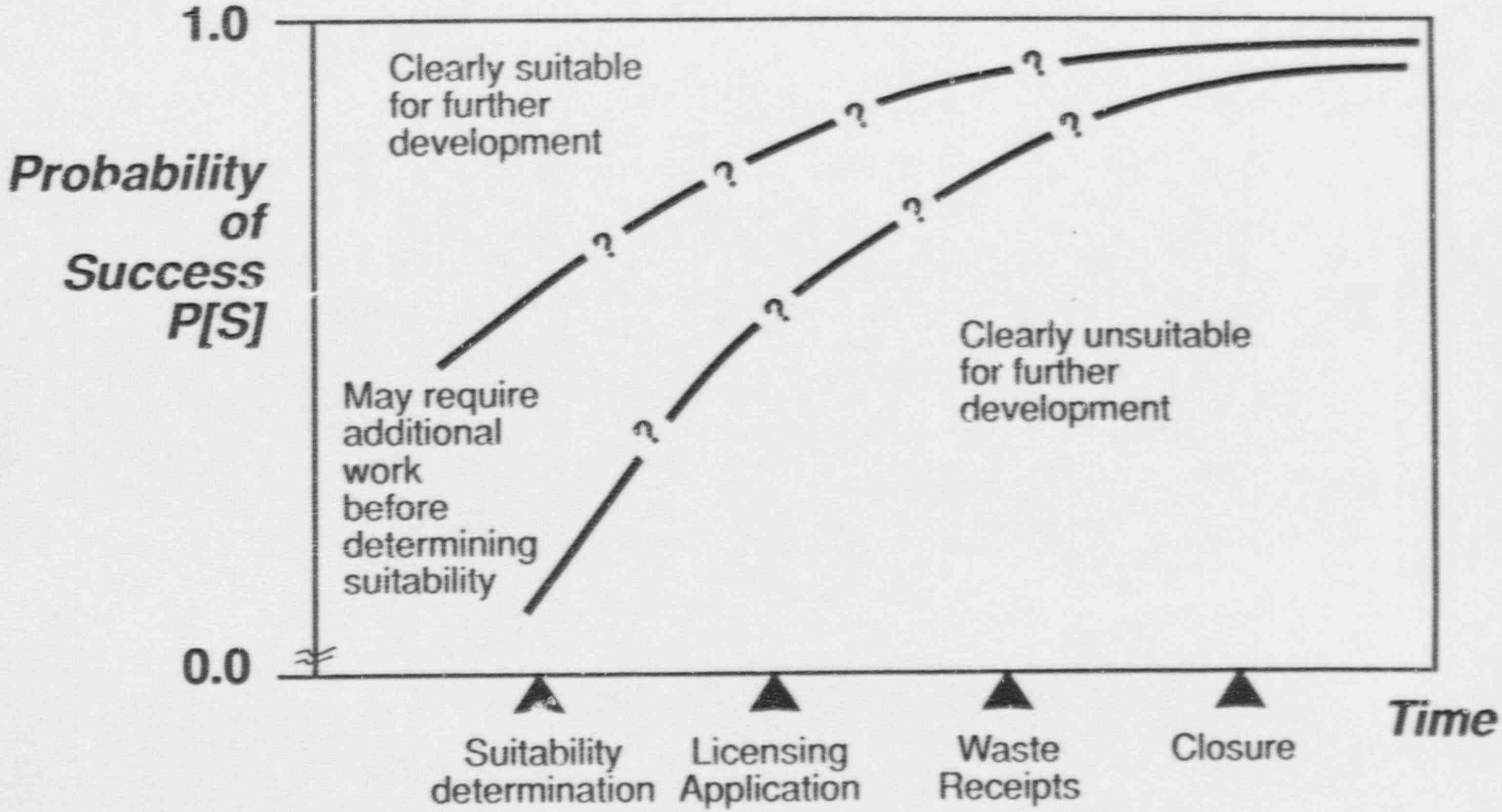
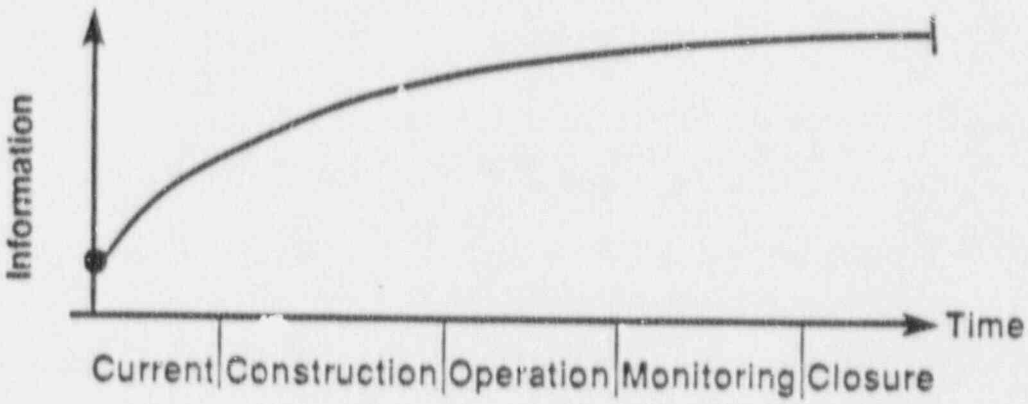
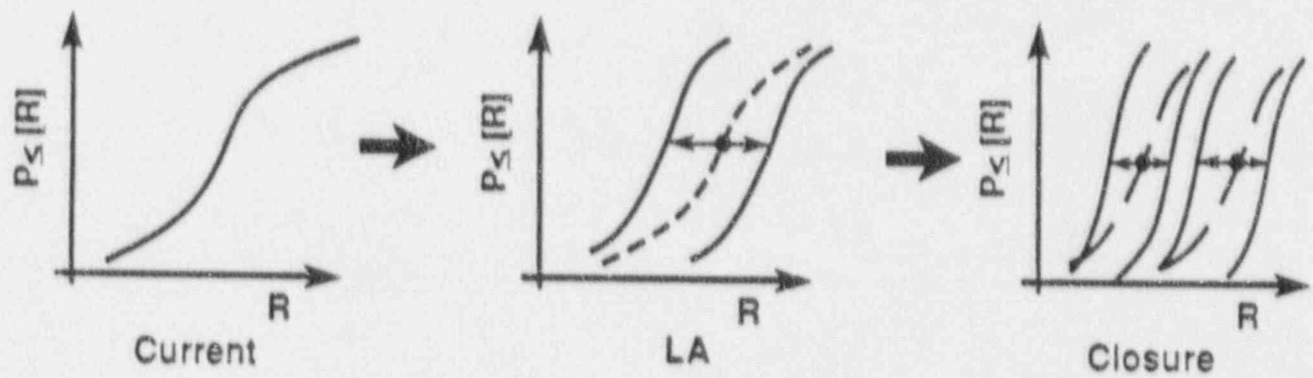
DOE Management Investment Decision



"Learning"



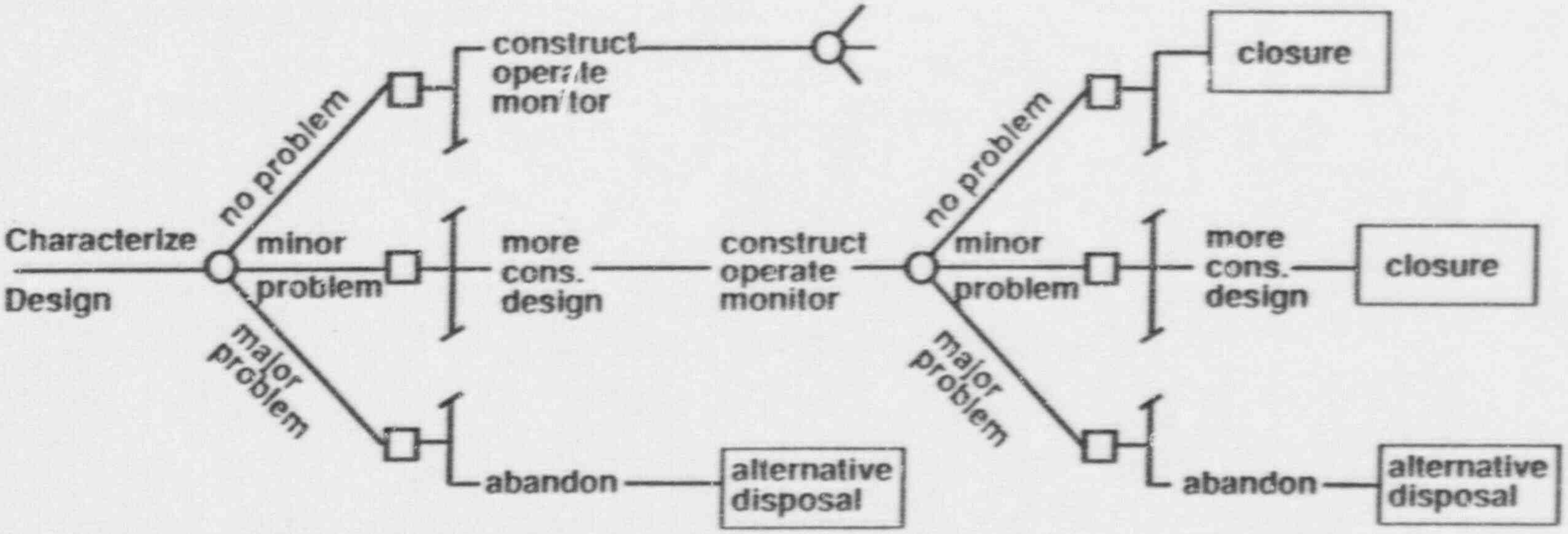
Information
Time
Current
Construction
Operation
Monitoring
Closure

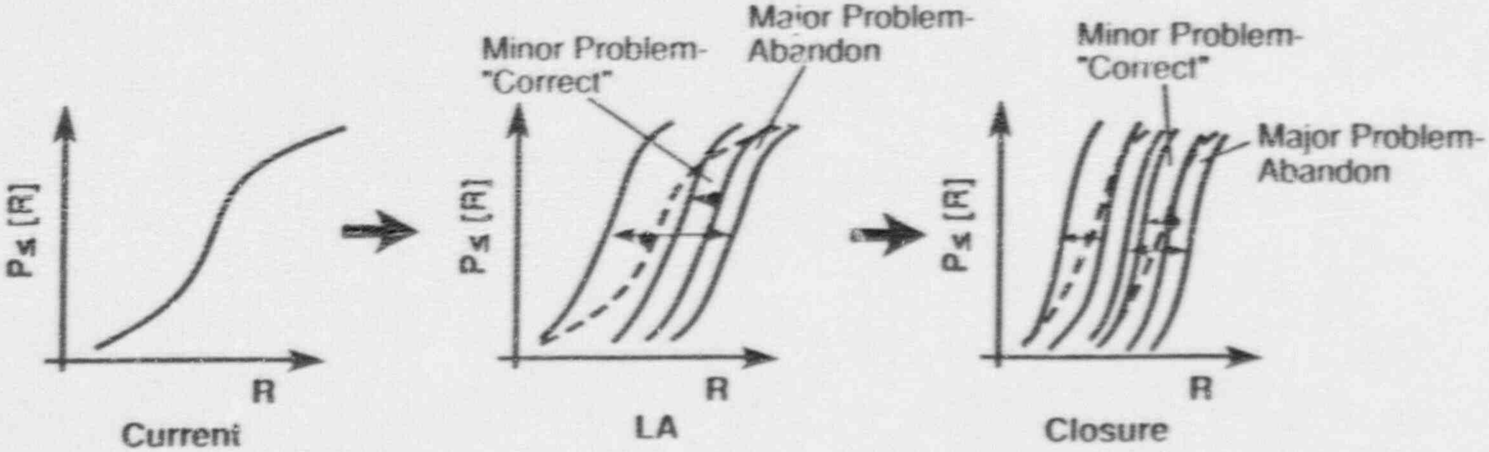


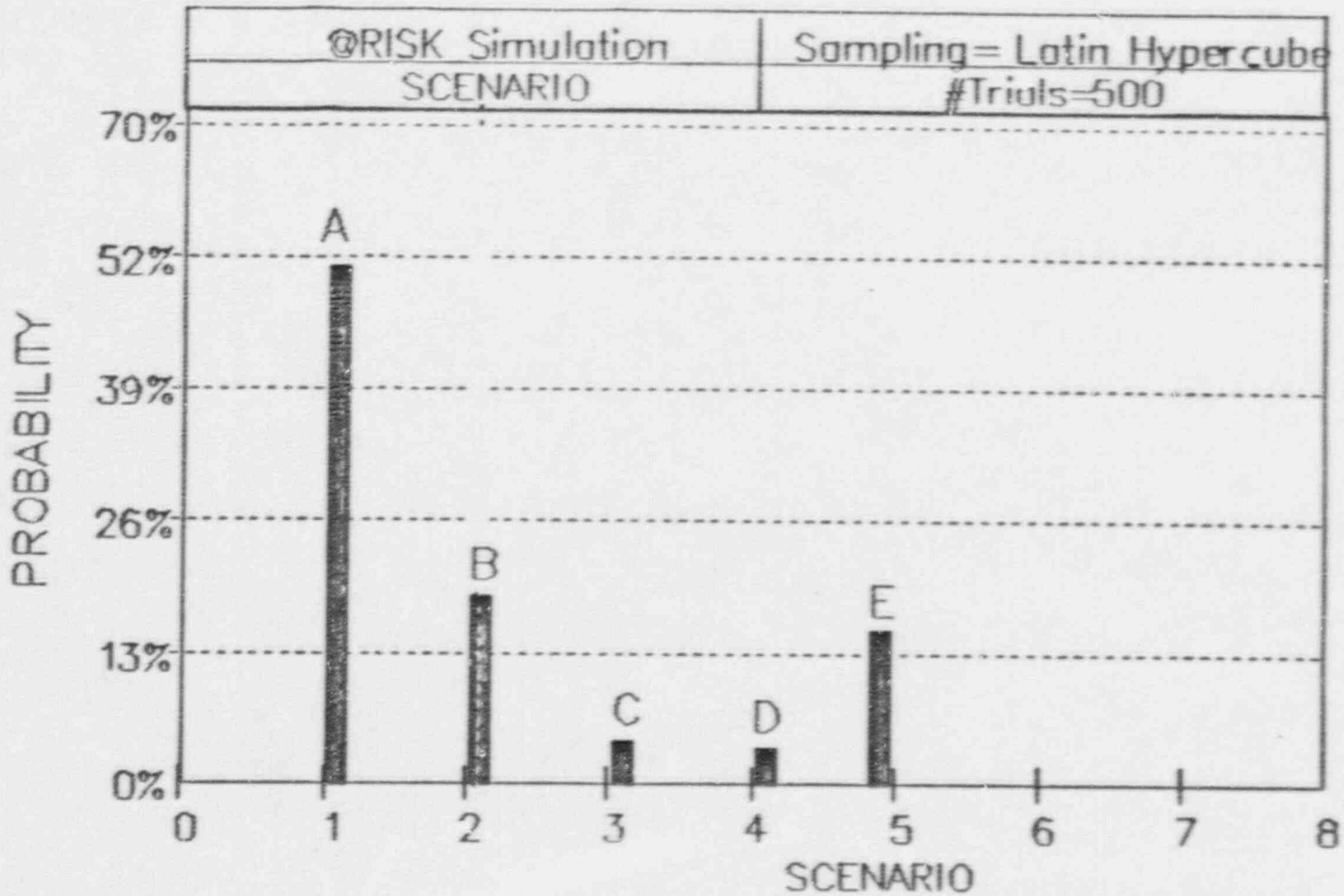
P≤ [R]
R
Current
P≤ [R]
R
LA
P≤ [R]
R
Closure

"Correcting"

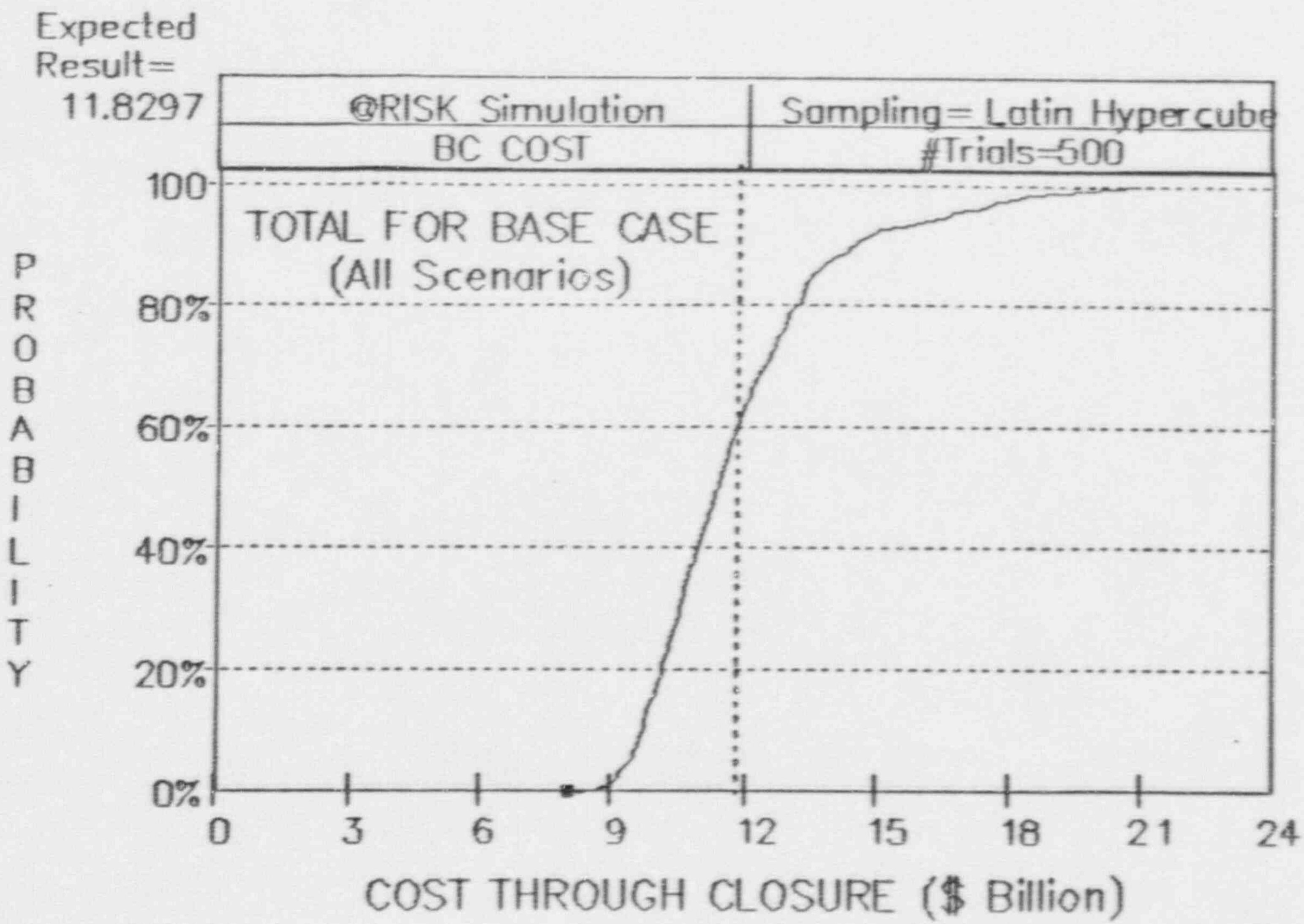
"Decision Rules"







@RISK Simulation
SCENARIO
Sampling= Latin Hypercube
#Trials=500
PROBABILITY
70%
52%
39%
26%
13%
0%
A
B
C
D
E
0
1
2
3
4
5
6
7
8
SCENARIO


Expected
Result=
11.8297
@RISK Simulation
Sampling= Latin Hypercube
BC COST
#Trials=500
TOTAL FOR BASE CASE
(All Scenarios)
PROBABILITY
100
80%
60%
40%
20%
0%
0
3
6
9
12
15
18
21
24
COST THROUGH CLOSURE ($ Billion)

MODELING

- Consequences predicted as function of parameters through models

$$C_i = f\{\underline{X}_i\}$$

$$C_i|Y = f\{\underline{X}_i, Y\}$$ specific scenario Y

- Uncertainty in parameters and models -> uncertainty in consequences

$$p[C_i] = f\{p[\underline{X}_i, E_i]\}$$

$$p[\underline{C}] = f\{p[\underline{X}, \underline{E}]\}$$ correlations among consequences

$$p\,[C_i|Y] = f\{p[\underline{X}_i, E_i|Y]\}$$ specific scenario Y

$$p[C_i] = f\{p[\underline{X}_i, E_i|Y], p[Y]\}$$

- Various techniques available to determine uncertainty in consequences as a function of uncertainty in parameters/models (e.g., Monte Carlo simulation)

PARAMETER UNCERTAINTY

- Properties may be

    complex (e.g., non-linear)

    spatially variable

    temporally variable

- Variability vs Uncertainty

- Correlations

- Estimates based on judgement/interpretation of <u>all</u> available data

    "qualified data" - higher emphasis

    other information - lower emphasis

- "Subjective" assessments are inevitable (never enough data)

    are non-unique and subject to controversy, hence must be adequately defensible to avoid project delay

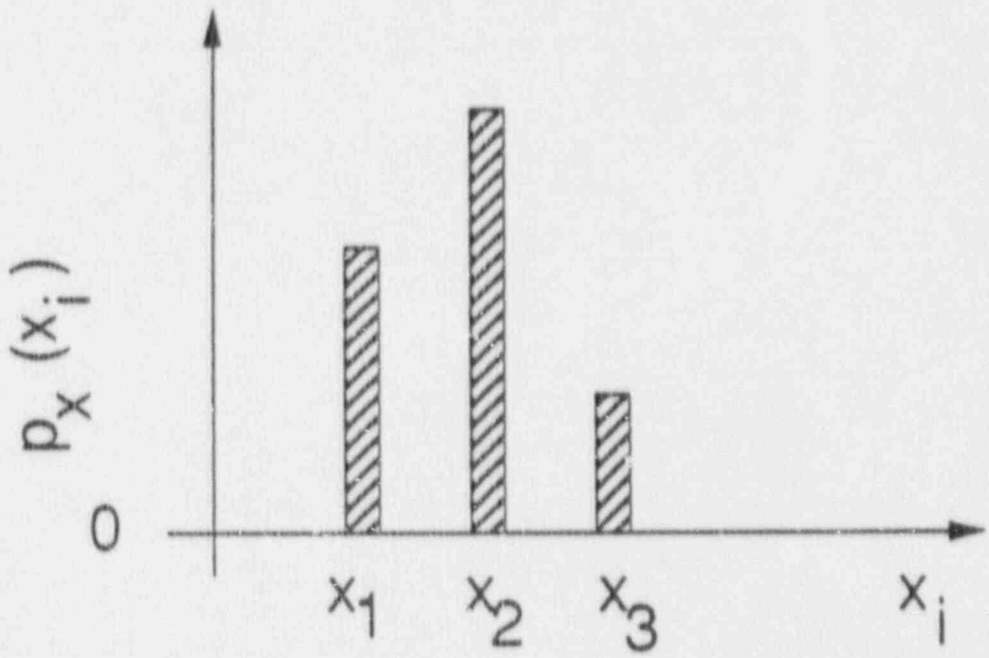
    should not be overly conservative, which would lead to unnecessary expense

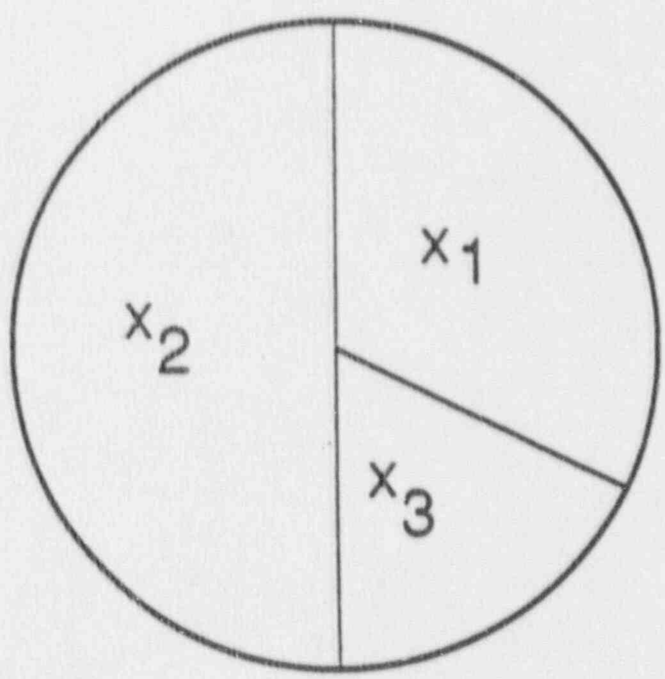
Sources of Uncertainty

- **Data Errors**
  - Random
  - Systematic
  - Accuracy limitations
- **Data Analysis**
  - Interpolated
  - Extrapolated
  - Analytically derived
    - lack of understanding regarding process
    - numerical simplification and approximation
- **Insufficient Data**
- **Non-representative Sample**
- **Spatial Variability and Nonuniformity**
  - Random
  - Trends
- **Temporal Variability**
  - Random
  - Trends

Probability Distributions

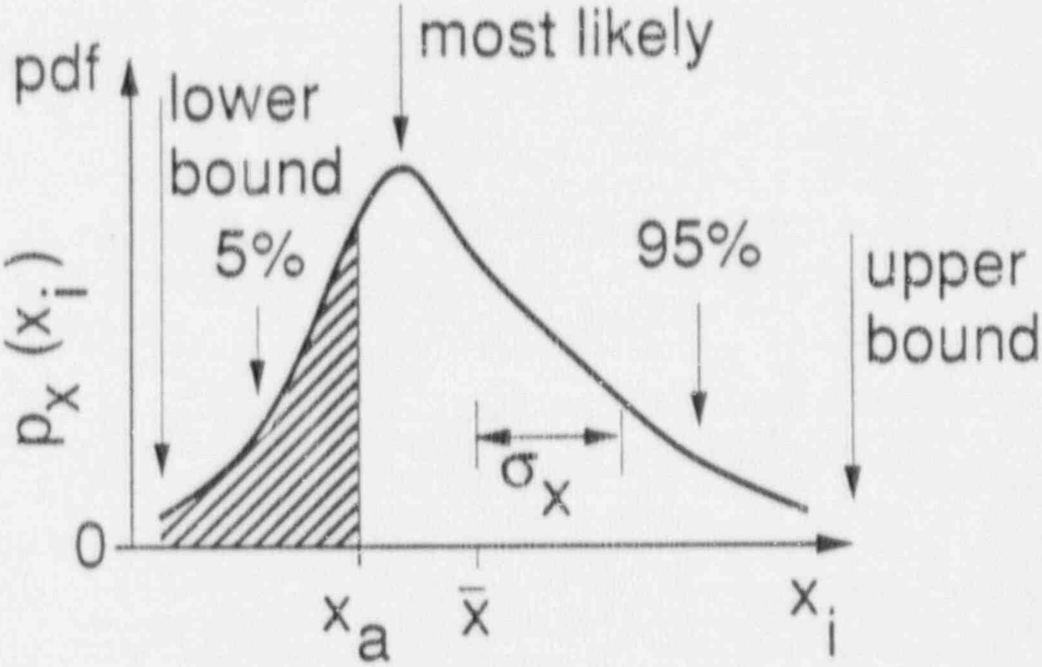
a) Discrete Variable (e.g., a scenario)



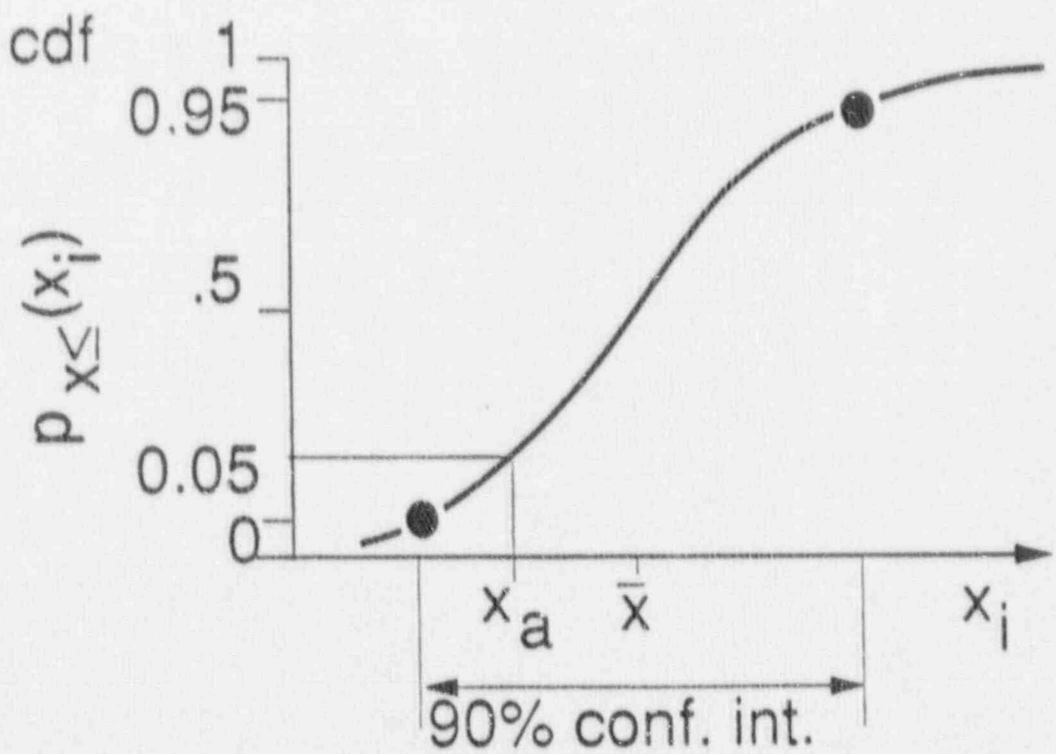


Probability Distributions

b) Continuous Variable (e.g., a parameter with a unique value)

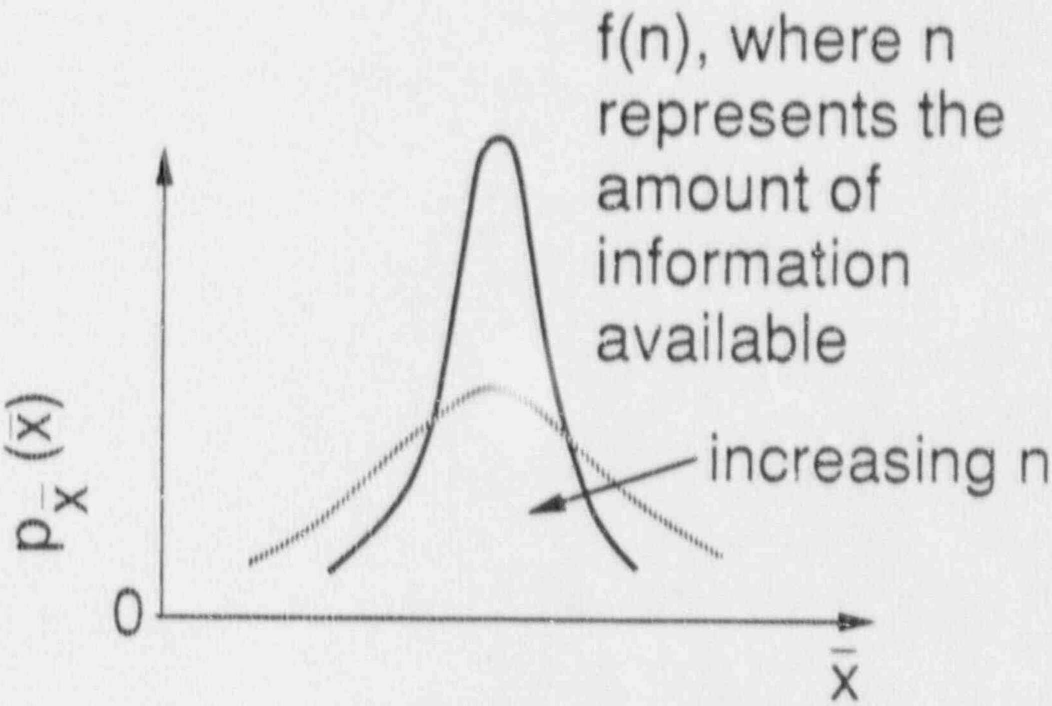


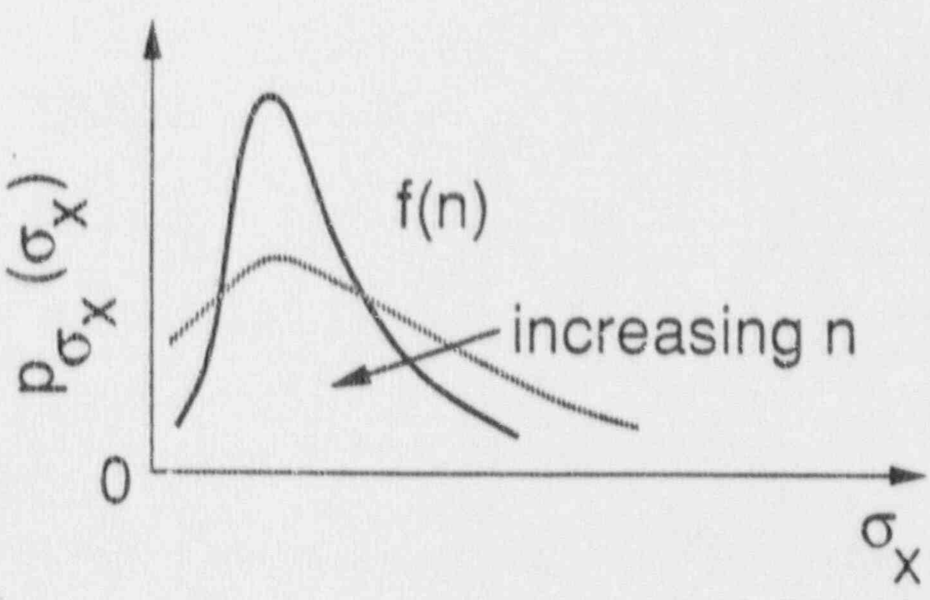
$$P_{X\leq}(x_a) = \int_{-\infty}^{x_a} p_X(x)\,dx$$



Probability Distributions

c) **Group Statistics** (e.g., a parameter with a population of values)





Potential Problems with Individual Assessments

- **Poor Quantification of Uncertainty**
- **Poor Problem Definition**
- **Unspecified Assumptions**
- **Uncorrected Biases**
  - "Motivational"
    - management
    - expert
    - conflict
    - conservative
  - "Cognitive"
    - anchoring
    - availability
    - base rate
    - coherence/conjunctive distortions
    - representativeness
    - overconfidence
- **Imprecision**
- **Lack of Credibility**

TECHNIQUE	POTENTIAL PROBLEMS Poor Quantification of Uncertainty	Poor Problem Definition	Uncorrected Biases/ Unspecified Assumptions	Imprecision	Lack of Credibility	Group Dynamics	Expense
INDIVIDUAL							
Self Assessment	●	○	●	●	●	NA	○
Informal Solicitation of Expert Opinion	●	●	●	●	◑	NA	◑
Calibrated Assessment	◑	●	◑	●	◑	NA	◑
Probability Encoding	○	○	○	◑	◑	NA	◑

● Technique does not significantly mitigate potential problem

◑ Technique partially mitigates potential problem

○ Technique effectively mitigates potential problem

Table 1. Evaluation of Subjective Assessment Techniques

Group Assessments

- **Sources of Differences in Individual Assessments**
  - Disagreement on assumptions or definitions
  - Failure to overcome assessment errors and biases
  - Different information sources
  - Disagreement on interpretations
  - Different opinions or beliefs
- **Possible Resolution Results**
  - Convergence
  - Consensus
    - agreed
    - forced
  - Disagreement

Group Assessments (cont.)

- **Mechanical Aggregation**
  - No interaction/simple
  - Resolve small differences
  - Achieve at least forced consensus
- **Behavioral Methods**
  - Interaction/expensive
  - Resolve large differences
  - Achieve at least agreed consensus (or disagreement)

TECHNIQUE	POTENTIAL PROBLEMS						
	Poor Quantification of Uncertainty	Poor Problem Definition	Uncorrected Biases/ Unspecified Assumptions	Imprecision	Lack of Credibility	Group Dynamics	Expense
GROUP (BEHAVIORAL)							
Open Forum	●	◑	●	●	◑	●	●
Delphi Panel	●	◑	◑	●	◑	○	●
Group Probability Encoding	○	○	○	◑	◑	◑	●
Formal Group Evaluation	○	○	○	◑	◑	◑	●

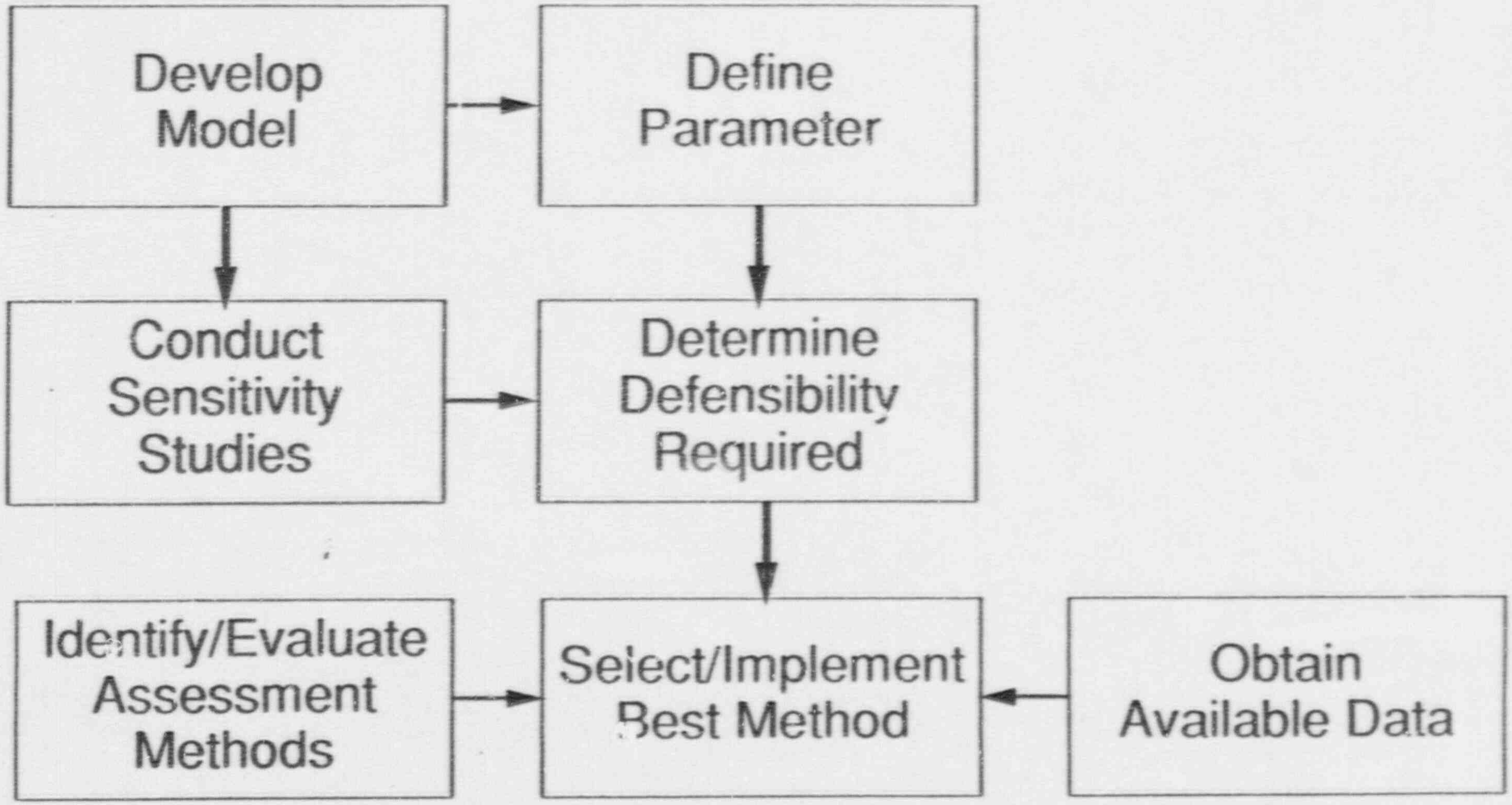
● Technique does not significantly mitigate potential problem

◑ Technique partially mitigates potential problem

○ Technique effectively mitigates potential problem

Table 1. Evaluation of Subjective Assessment Techniques

Recommendation



Recommendations (cont.)

- **Select Cheapest Method which Satisfies Defensibility Requirements**
- **Ranging from Low to High Defensibility**
  - Self assessment → Individual assessment
  - Informal expert opinion → Individual assessment
  - Probability encoding → Individual assessment
  - Multiple informal expert opinions and mechanical aggregation → Forced consensus
  - Open forum → Convergence, agreed consensus, or disagreement
  - Delphi panel → Forced consensus or disagreement
  - Probability encoding and formal group evaluation → Convergence, agreed consensus, or disagreement

Summary/Conclusions

- **Subjective Probability Assessments**
  - Necessary due to data base insufficiencies
  - Non-unique → potentially controversial
  - Parameter significance → defensibility requirements
  - Cost vs. defensibility
- **Individual and Group Assessments**
  - Potential problems
  - Available techniques
  - Evaluations
  - Recommendations

EPRI

EPRI / EEI HLW METHODOLOGY DEVELOPMENT PROJECT

EPRI
Performance Assessment Workshop
December 4-6, 1990

Robert A. Shaw
Electric Power Research Institute

Robin McGuire
Risk Engineering, Inc.

HLW PERFORMANCE ASSESSMENT WORKSHOP

Agenda

Tuesday, December 4

8:30	Introductions, Agenda, Goals of Meeting
9:30	EPRI Process
11:30	Lunch
2:00	Golder Process
5:00	Adjourn

Wednesday, December 5

8:00	DOE Process
11:30	Lunch
1:00	NRC Process
2:30	Discussion of Processes
4:00	Working Groups
5:00	Adjourn

Thursday, December 6

8:00	Working Groups (continued)
10:00	Reports from Working Groups
11:30	Lunch
12:30	Discussion, Wrap Up, Future Plans
3:30	Adjourn

EPRI HLW Project Objectives

- To develop an integrated methodology for early site performance assessment and to identify and prioritize crucial issues
- To involve DOE in this methodology development and its implementation

EPRI High Level Waste Project

Methodology Development Team

Name	Affiliation	Expertise
Daniel B. Bullen	Georgia Tech	Waste Package
Neville Cook	Univ. of Calif, Berkeley	Rock Mechanics
Kevin Coppersmith	Geomatrix Consultants	Seismic Geology
Ralph L. Keeney	Univ. of Southern California	Risk/Decision Analysis
John M. Kemeny	University of Arizona	Rock Mechanics
Austin Long	University of Arizona	Climatology
Robin K. McGuire	Risk Engineering	Risk Analysis
F. Joseph Pearson, Jr.	Consultant	Geochemistry
Frank W. Schwartz	Ohio State University	Hydrology
Michael Sheridan	State Univ. of NY, Buffalo	Volcanology
Robert A. Shaw	EPRI	Project Manager
J. Carl Stepp	EPRI	Seismology & Geophysics
Robert F. Williams	EPRI	HLW Sciences
Robert Youngs	Geomatrix Consultants	Geotechnical Engineering
Delbert S. Barth	UNLV/ERC	Observer
Russ Dyer	Department of Energy	Observer

High Level Waste – Methodology Dev Team

- Identifying alternative descriptions of site characteristics
  - Identify alternative scenarios
  - Assign probabilities
- Explore calculational methods
  - Consider integrated effects of scenarios
- Demonstrate integration among disciplines
- Demonstrate how calculations can be used to show site suitability

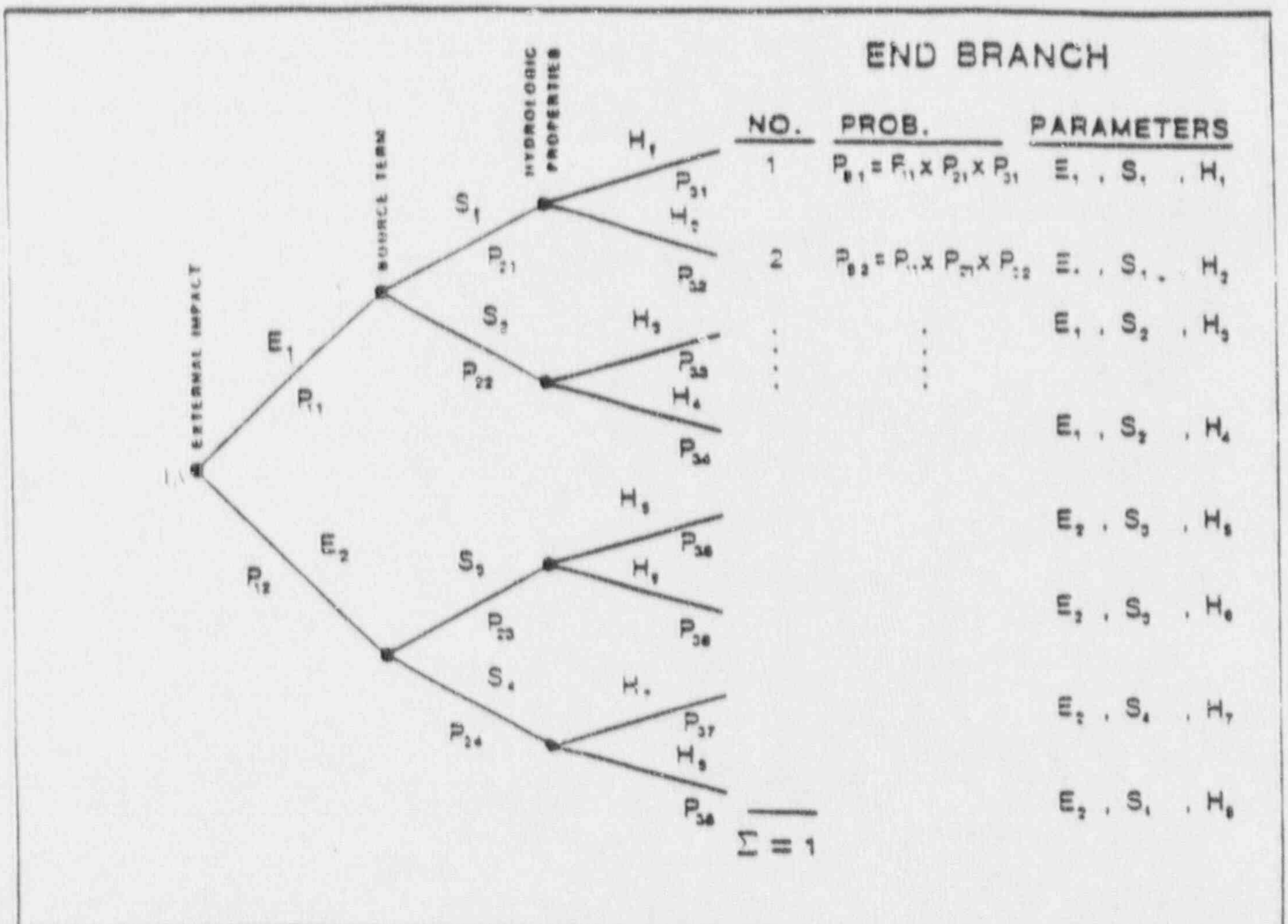
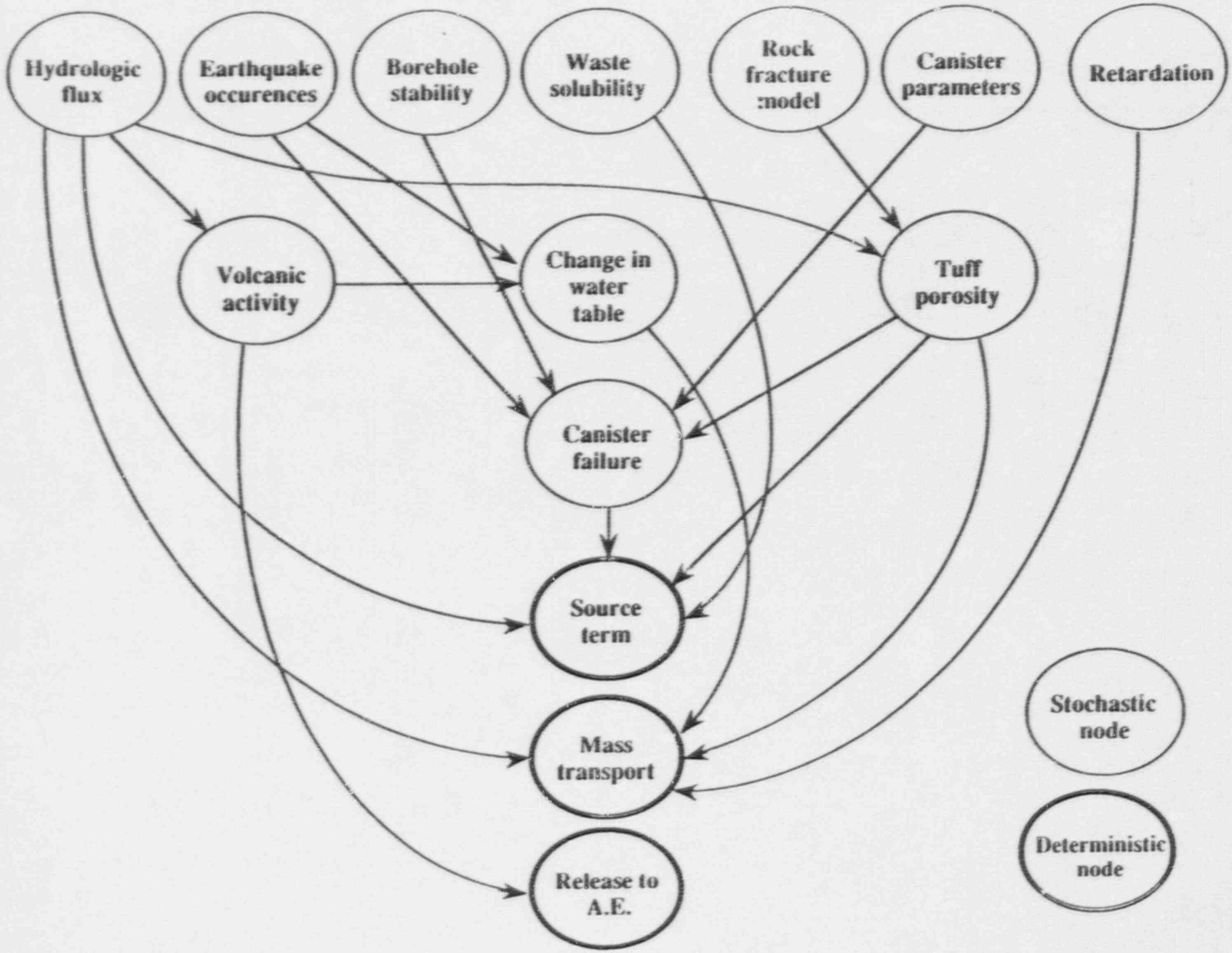


Figure 9-1. Example logic tree.

Influence diagram for 9.3



Technical Issues

- Keeping in mind that the MDT results are illustrative, the following are found to be more influential on site performance
- Hydrology
  - — Infiltration (recharge) from precipitation
  - — Water flow pathways
    - Influenced by extent of rock fracture and porosity
  - — Significant rise in water table
- Geochemistry
  - — Uranium solubility, as influenced by dissolution chemistry and temperature
  - — Chemical retardation of released radioisotopes

Conclusions

The use of multi-disciplinary scientific and engineering expertise to conduct a risk-based evaluation of a HLW repository is achievable with current knowledge and technology.

- A structured approach is required; the workshop format is suited to this approach.
- The use of logic trees is a convenient and credible format
- Results of the methodology should be obtained during the process of model development, i.e., the process should be iterative.

A methodology of this type can be applied on a larger scale, in which a larger body of expertise participates. This application will lead to realistic (rather than simple demonstrative) results.

Phase 3

- Series of workshops on highest priority technical areas identified in Phase 2
  - Sponsored by DOE
  - Used by EPRI to updats and revise P/A methodology
  - One to three workshops per year
  - Significant independent technical expert input to DOE

OVERVIEW OF DOE'S ACTIVITIES TO FOCUS TESTING PROGRAM ON SITE SUITABILITY

J. YOUNKER
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

L. RICKERTSEN
WESTON TECHNICAL SUPPORT TEAM

EPRI PERFORMANCE ASSESSMENT WORKSHOP
DECEMBER 4-6, 1990
WASHINGTON, D.C.

SUMMARY OF DOE PRESENTATIONS

- BACKGROUND: 10 CFR PART 960, SITE CHARACTERIZATION & SITE SUITABILITY
- PLAN TO RE-EVALUATE 10 CFR PART 960 DISQUALIFYING CONDITIONS
- PERFORMANCE ASSESSMENT SUPPORT TO EVALUATION OF SUITABILITY AND ITERATIVE PRIORITIZATION OF SITE TESTING
- STATUS OF TEST PRIORITIZATION TASK

PURPOSE OF SITE SUITABILITY EVALUATIONS

- EARLY SITE SUITABILITY EVALUATIONS FOCUS ATTENTION ON NATURAL CONDITIONS OR FEATURES THAT INDICATE THE SITE IS NOT SUITABLE

- COMPREHENSIVE SUITABILITY EVALUATION REQUIRED BY 10 CFR PART 960 PRIOR TO RECOMMENDATION OF A SITE FOR REPOSITORY DEVELOPMENT

THREE PHASES OF SUITABILITY EVALUATIONS

PHASE 1 UNSUITABILITY: RE-EVALUATION OF DISQUALIFYING CONDITIONS OF 10 CFR PART 960

PHASE 2 ITERATIVE SUITABILITY: PERIODIC RE-EVALUATION OF DISQUALIFYING CONDITIONS AND QUALIFYING CONDITIONS OF 10 CFR PART 960 - HIGHER LEVEL FINDINGS MAY BE MADE ON SOME DISQUALIFYING CONDITIONS DURING THIS PHASE; AND

PHASE 3 COMPREHENSIVE SUITABILITY: HIGHER LEVEL FINDINGS FOR ALL DISQUALIFYING AND QUALIFYING CONDITIONS ARE MADE; THIS PHASE IS CLOSELY LINKED TO LICENSIBILITY OF THE SITE

10 CFR PART 960 HIGHER LEVEL FINDINGS, APPENDIX III REQUIRED FOR COMPREHENSIVE SUITABILITY EVALUATION

DISQUALIFYING CONDITION	QUALIFYING CONDITION
THE EVIDENCE SUPPORTS A FINDING THAT THE SITE IS DISQUALIFIED OR IS LIKELY TO BE DISQUALIFIED	THE EVIDENCE SUPPORTS A FINDING THAT THE SITE CANNOT MEET THE QUALIFYING CONDITION OR IS UNLIKELY TO BE ABLE TO MEET THE QUALIFYING CONDITION, AND THEREFORE THE SITE IS DISQUALIFIED
OR	OR
THE EVIDENCE SUPPORTS A FINDING THAT THE SITE IS NOT DISQUALIFIED ON THE BASIS OF THAT EVIDENCE AND IS NOT LIKELY TO BE DISQUALIFIED	THE EVIDENCE SUPPORTS A FINDING THAT THE SITE MEETS THE QUALIFYING CONDITION AND IS LIKELY TO CONTINUE TO MEET THE QUALIFYING CONDITION

10 CFR PART 960 TECHNICAL DISQUALIFYING CONDITIONS

TECHNICAL GUIDELINE	CONDITION
GEOHYDROLOGY	< 1,000 YR GROUND-WATER TRAVEL TIME
EROSION	INSUFFICIENT THICKNESS TO PLACE REPOSITORY AT 200 M DEPTH
DISSOLUTION	ACTIVE DISSOLUTION THAT COULD RESULT IN LOSS OF WASTE ISOLATION
TECTONICS	FAULT MOVEMENT/GROUND MOTION EXPECTED TO LEAD TO LOSS OF WASTE ISOLATION
HUMAN INTERFERENCE	SIGNIFICANT PATHWAYS EXIST OR RESOURCE EXTRACTION OUTSIDE CONTROLLED AREA EXPECTED TO CAUSE LOSS OF WASTE ISOLATION
ROCK CHARACTERISTICS	RISKS TO HEALTH & SAFETY USING REASONABLY AVAILABLE TECHNOLOGY
PRECLOSURE TECTONICS	EXPECTED FAULT MOVEMENT REQUIRES BEYOND REASONABLY AVAILABLE TECHNOLOGY
PRECLOSURE HYDROLOGY	EXPECTED GROUND-WATER CONDITIONS REQUIRE BEYOND REASONABLY AVAILABLE TECHNOLOGY
TOTAL SYSTEM	GEOLOGIC SETTING ALLOWS COMPLIANCE WITH REQUIREMENTS

GENERAL APPROACH FOR PHASE 1

- RE-EVALUATE TECHNICAL POSTCLOSURE AND PRECLOSURE DISQUALIFYING CONDITIONS OF 10 CFR PART 960 (NON-TECHNICAL GUIDELINES MAY NOT BE RE-EVALUATED IN PHASE 1)

- PHASE 1 PRODUCT WILL BE SUBJECTED TO AN EXTERNAL TECHNICAL OR PEER REVIEW

KEY ELEMENTS OF THE PHASE 1 APPROACH

- THE DISQUALIFYING CONDITIONS WILL BE RE-EVALUATED

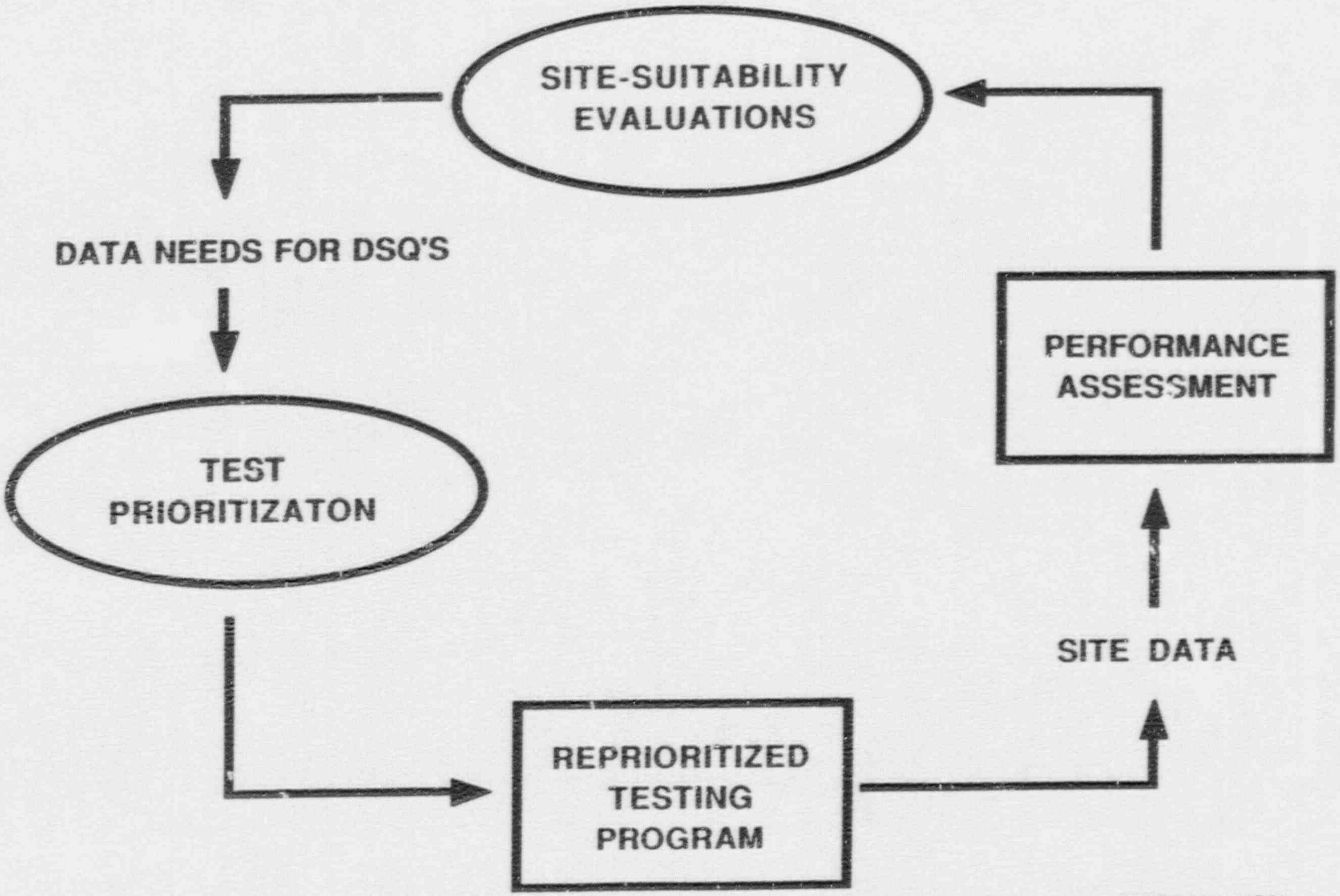
- THE SCOPE OF THE DISQUALIFYING CONDITIONS WILL NOT BE EXPANDED BUT RATHER MADE MORE EXPLICIT WHERE NECESSARY FOR RE-EVALUATION

- A CLOSE RELATIONSHIP WILL BE MAINTAINED WITH THE TEST PRIORITIZATION TASK — DATA WEAKNESSES/ STRENGTHS WILL BE FACTORED INTO THE BASIS FOR TEST PRIORITIES

- OUTSIDE ASSESSMENTS (e.g., EPRI, GOLDER, STATE) OF SITE CONDITIONS RELEVANT TO 10 CFR 960 WILL BE ACKNOWLEDGED AND CONSIDERED

PHASE I

TEST PRIORITIZATION FOR SITE-SUITABILITY



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TENTATIVE TASK PLAN FOR PHASE 1: RE-EVALUATE DSQ'S

STEP 1	PREPARE MANAGEMENT PLAN AND GRADE QA REQUIREMENTS
STEP 2	ESTABLISH A MULTIDISCIPLINE CORE TEAM TO PERFORM ANALYSES & PREPARE REPORTS
STEP 3	ANALYZE ALL RELEVANT DATA & ANALYSES POST-EA
STEP 4	DEVELOP A RE-EVALUATION OF TECHNICAL DSQ'S
STEP 5	CONDUCT TECHNICAL/PEER REVIEW
STEP 6	REVISE PHASE 1 PRODUCT PER PEER REVIEW COMMENTS

POTENTIAL CONCERNS WITH APPROACH

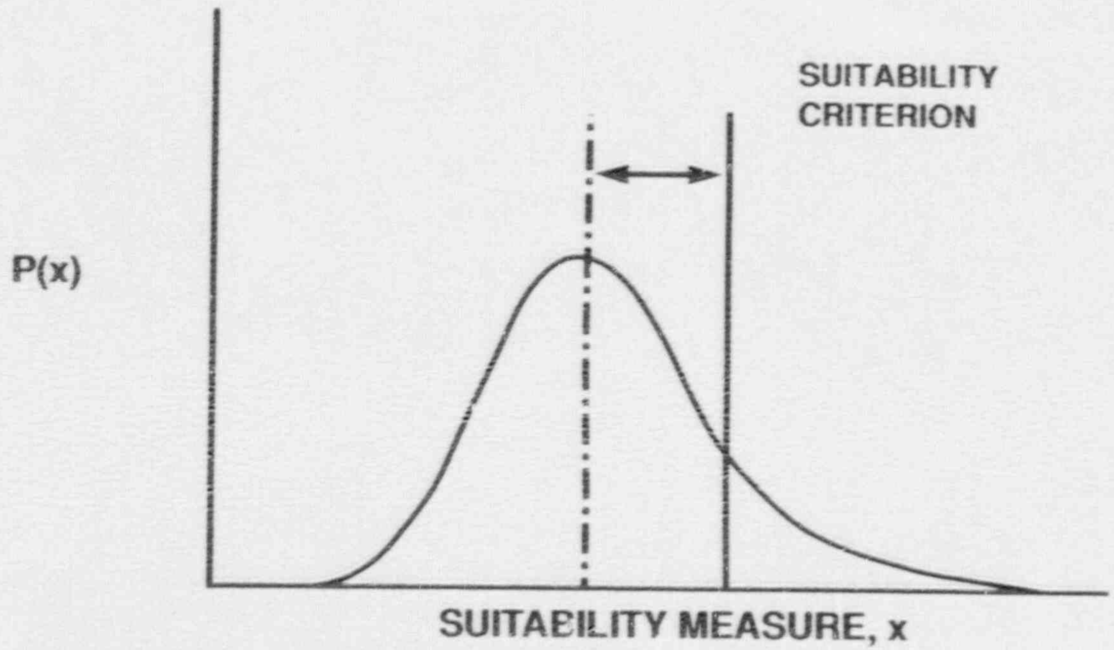
- 10 CFR PART 960 DISQUALIFYING CONDITIONS DO NOT EXPLICITLY INCLUDE SOME CONCERNS (I.E. VOLCANISM, HYDRO–TECTONIC AFFECTS DO NOT HAVE DSQ's IN 10 CFR 960)

PROPOSED WAYS TO ADDRESS CONCERN:

1. RELY ON ASSESSMENTS OF TOTAL SYSTEM PERFORMANCE - VOLCANISM, ETC., CONCERNS WOULD BE EVALUATED AS DISRUPTIVE SCENARIOS

2. UTILIZE OUTSIDE PARALLEL STUDIES THAT HAVE ADDRESSED THESE CONCERNS IN THE RE–EVALUATION

CONCEPTS OF SUITABILITY MEASURES AND SUITABILITY CRITERIA WILL BE USED IN SUITABILITY EVALUATIONS



SUITABILITY MEASURE: VARIABLE INDICATING DEGREE OF UNSUITABILITY OR SUITABILITY IN TERMS OF SITE FEATURE OR CONDITION

SUITABILITY CRITERION: VALUE OF SUITABILITY MEASURE THAT MUST BE ACHIEVED

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CATEGORIES OF MEASURES UNDER CONSIDERATION

- MEASURES BASED ON POTENTIAL FOR UNACCEPTABLE PERFORMANCE
- MEASURES BASED ON POTENTIAL FOR UNACCEPTABLE DISTURBANCES TO PRESENT SITE CONDITIONS
- MEASURES BASED ON POTENTIAL FOR UNACCEPTABLE RESIDUAL UNCERTAINTIES

DEVELOPMENT OF PERFORMANCE–BASED MEASURES

1. IDENTIFY PERFORMANCE MEASURES (PM) AND CRITERIA (CR)

   EXAMPLE: PM : M, 10,000–YR CUMULATIVE RELEASES
   CR : M < EPA STANDARD

2. IDENTIFY SUITABILITY MEASURES TO WHICH PERFORMANCE WOULD BE SENSITIVE

3. IDENTIFY SUBSET OF SUITABILITY MEASURES THAT CAN BE EVALUATED EARLY

4. DEFINE VALUES OR COMBINATIONS OF VALUES (e.g. CRITERIA) FOR MEASURES THAT WOULD INDICATE UNACCEPTABLE PERFORMANCE

DEVELOPMENT OF DISTURBANCE–BASED MEASURES

1. IDENTIFY FEATURES OR CONDITIONS OF CONCERN

   EXAMPLE: TECTONIC ACTIVITY AT SITE

2. IDENTIFY SUITABILITY MEASURES FOR THESE FEATURES OR CONDITIONS

   EXAMPLE: FAULT DISPLACEMENT DURING QUATERNARY

3. SELECT THOSE MEASURES THAT CAN BE EVALUATED FROM EARLY TESTING

4. DETERMINE VALUES FOR MEASURES THAT INDICATE UNACCEPTABLE CONDITIONS OR FEATURES

DEVELOPMENT OF RESIDUAL–UNCERTAINTY BASED MEASURES

1. IDENTIFY MAJOR SOURCES OF UNCERTAINTY IN SITE FEATURES AND CONDITIONS

2. ESTABLISH SIGNIFICANCE OF UNCERTAINTIES

   EXAMPLE: HIGH SIGNIFICANCE = INABILITY TO DEMONSTRATE PERFORMANCE CRITERIA ARE MET

3. ESTABLISH LIMITS TO COST/SCHEDULE FOR UNCERTAINTY REDUCTION

EXAMPLES OF POSSIBLE SUITABILITY MEASURES FOR EARLY EVALUATIONS

GEOHYDROLOGY

SPECIAL CRITERION FOR DSQ: EXPECTED TRAVEL TIME ALONG ANY FLOW PATH THAT COULD CAUSE MEAN CUMULATIVE RELEASE IN 10,000 YRS > 10% EPA STANDARD

PERFORMANCE-BASED MEASURES	DISTURBANCE-BASED MEASURES	RESIDUAL-UNCERTAINTY BASED MEASURES
EXPECTED AGE OF GROUND-WATER NEAR WATER TABLE	TECTONIC EFFECTS ON FLOW PATHS OR INFILTRATION RATE	COST/SCHEDULE TO REDUCE UNCERTAINTY IN PREFERENTIAL PATHS
EXPECTED INFILTRATION RATE AT REPOSITORY HORIZON	TECTONIC EFFECTS ON SZ GRADIENT	COST/SCHEDULE TO REDUCE UNCERTAINTY IN MATRIX/FRACTURE INTERACTIONS
MEASURE RELATED TO EFFECT OF PREFERENTIAL PATHS	EFFECTS OF EXTREME CLIMATE CHANGE ON WATER TABLE, INFILTRATION, SZ GRADIENTS	COST/SCHEDULE TO REDUCE UNCERTAINTY IN UNDETECTED FEATURES THAT COULD PROVIDE FLOW PATHS
MEASURE RELATED TO MATRIX/FRACTURE INTERACTIONS		

EXAMPLES OF POSSIBLE SUITABILITY MEASURES FOR EARLY EVALUATIONS

EROSION

SPECIAL CRITERION FOR DSQ: DEPTH OF POTENTIAL UNDERGROUND FACILITY BELOW DIRECTLY OVERLYING SURFACE

PERFORMANCE-BASED MEASURES	DISTURBANCE-BASED MEASURES	RESIDUAL-UNCERTAINTY BASED MEASURES
MEAN EROSION RATE OF SURFACE MATERIALS DIRECTLY ABOVE POTENTIAL UNDERGROUND FACILITY	NONE	NONE

SPECIAL CRITERION FOR DSQ: MEAN DISSOLUTION RATE OF HOST ROCK
[NOTE: COULD ALSO SERVE AS PERFORMANCE-BASED MEASURE]

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EXAMPLES OF POSSIBLE SUITABILITY MEASURES FOR EARLY EVALUATIONS

TECTONICS

SPECIAL CRITERION FOR DSQ: EXPECTED NATURE AND RATES OF FAULT MOVEMENT SUCH THAT MEAN CUMULATIVE RELEASE IN 10,000 YEARS WOULD EXCEED 10% OF EPA STANDARD

PERFORMANCE–BASED MEASURES	DISTURBANCE–BASED MEASURES	RESIDUAL–UNCERTAINTY BASED MEASURES
EXPECTED DIRECT RELEASE IN ANY VOLCANIC EVENT OVER NEXT 10^4 YRS	LATE QUATERNARY FAULT–INDUCED DISPLACEMENTS WITHIN REPOSITORY BLOCK	COST/SCHEDULE TO REDUCE UNCERTAINTY IN MAGNITUDE OR FREQUENCY OF FAULTING
EXPECTED DIRECT RELEASE IN ANY TECTONIC EVENT IN NEXT 10^4 YRS	LATE QUATERNARY VOLCANISM WITHIN REPOSITORY BLOCK	COST/SCHEDULE TO REDUCE UNCERTAINTY IN RELATIONSHIP BETWEEN EXPECTED TECTONIC ACTIVITY & PERFORMANCE
	LATE QUATERNARY HYDROTHERMAL DEPOSITS WITHIN THE REPOSITORY BLOCK	COST/SCHEDULE TO REDUCE UNCERTAINTY IN RELATIONSHIP BETWEEN HYDROTHERMAL DEPOSITS & PERFORMANCE
	STRESS/STRAIN CONDITIONS THAT COULD SIGNIFICANTLY MODIFY FLOW PATHS OR FLUX	COST/SCHEDULE TO REDUCE UNCERTAINTY IN EFFECTS OF STRESS/STRAIN ON PERFORMANCE

EXAMPLES OF POSSIBLE SUITABILITY MEASURES FOR EARLY EVALUATIONS

POSTCLOSURE SYSTEM GUIDELINE

PERFORMANCE-BASED MEASURES:	EXPECTED CUMULATIVE RELEASES FOR GAS + WATER PATHWAYS IN 10,000 YRS
	EXPECTED PEAK FRACTIONAL RELEASE RATE TO ACCESSIBLE ENVIRONMENT DUE TO INSTANTANEOUS RELEASE OF INVENTORY FROM WASTE PACKAGES
	SPECIAL MEASURES FOR GASEOUS RELEASE:
	AIR FLOW RATES
	TRANSPORT PARAMETERS

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EXAMPLES OF POSSIBLE CRITERIA

GUIDELINE	CRITERION TYPE	MEASURE	CRITERION
GEOHYDROLOGY	DSQ	T, EXPECTED TRAVEL TIME ALONG FLOW PATH THAT COULD CAUSE MEAN CUMULATIVE RELEASE IN 10,000 YRS > 10% EPA STANDARD	T > 1,000 YRS
GEOHYDROLOGY	PERFORMANCE	EXPECTED INFILTRATION RATE AT REPOSITORY HORIZON, AVERAGED OVER REPOSITORY BLOCK	I < 50 MM/YR
GEOHYDROLOGY	DISTURBANCE	TECTONIC EFFECTS ON SZ GRADIENT	PROBABILITY OF 100X INCREASE IN 10,000 YRS < .0001
GEOHYDROLOGY	UNCERTAINTY	COST/SCHEDULE TO REDUCE UNCERTAINTY IN PREFERENTIAL PATHWAYS	COST < 20M & < 7 YEARS

PROBLEMS ANTICIPATED IN DEFINING MEASURES AND CRITERIA FOR EARLY SITE SUITABILITY EVALUATIONS

DISQUALIFYING CONDITIONS

- SOME CONDITIONS NOT INTENDED TO BE EVALUATED BEFORE END OF SITE CHARACTERIZATION
- POTENTIAL FOR DISQUALIFYING A SUITABLE SITE DUE TO INCOMPLETE INFORMATION
- DEFINITION OF TERMS – EXPECTED, LIKELY, SIGNIFICANT, COMPATIBLE WITH WASTE ISOLATION AND CONTAINMENT

PROBLEMS ANTICIPATED IN DEFINING MEASURES AND CRITERIA FOR EARLY SITE SUITABILITY EVALUATIONS

(CONTINUED)

PERFORMANCE–BASED MEASURES

- DIFFICULTY IN EVALUATING COMPLEX CONDITIONS WITH LIMITED SITE INFORMATION
- IDENTIFYING SINGLE MEASURE FOR SUITABILITY IS DIFFICULT BECAUSE MANY FACTORS CONTRIBUTE TO WASTE ISOLATION
- PERFORMANCE ASSESSMENTS WILL BE INCONCLUSIVE DUE TO LARGE UNCERTAINTIES IN CONCEPTUAL MODELS

PROBLEMS ANTICIPATED IN DEFINING MEASURES AND CRITERIA FOR EARLY SITE SUITABILITY EVALUATIONS

(CONTINUED)

DISTURBANCE–BASED MEASURES

- DIFFICULT TO RELATE SOME CONDITIONS/PROCESSES TO PERFORMANCE
- DEFINING LEVEL OF CONDITION THAT SHOULD RESULT IN DISQUALIFICATION WILL BE PROBLEMATIC
- LEVEL OF UNCERTAINTY IN CONDITIONS WILL BE DIFFICULT TO ADDRESS

PROBLEMS ANTICIPATED IN DEFINING MEASURES AND CRITERIA FOR EARLY SITE SUITABILITY EVALUATIONS

(CONTINUED)

RESIDUAL UNCERTAINTY–BASED MEASURES

- QUANTIFYING CURRENT UNCERTAINTIES IS PROBLEMATIC
- DIFFICULT TO IDENTIFY UNACCEPTABLE LEVELS OF RESIDUAL UNCERTAINTIES
- DEFINING CRITERIA IN COST/SCHEDULE TERMS IS DIFFICULT BECAUSE TRADEOFFS ARE POSSIBLE

OVERVIEW OF DOE'S ACTIVITIES TO FOCUS TESTING PROGRAM ON SITE SUITABILITY

A. DUCHARME
SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NM

EPRI PERFORMANCE ASSESSMENT WORKSHOP
DECEMBER 4-6, 1990
WASHINGTON, D.C.

SUMMARY OF DOE PRESENTATIONS

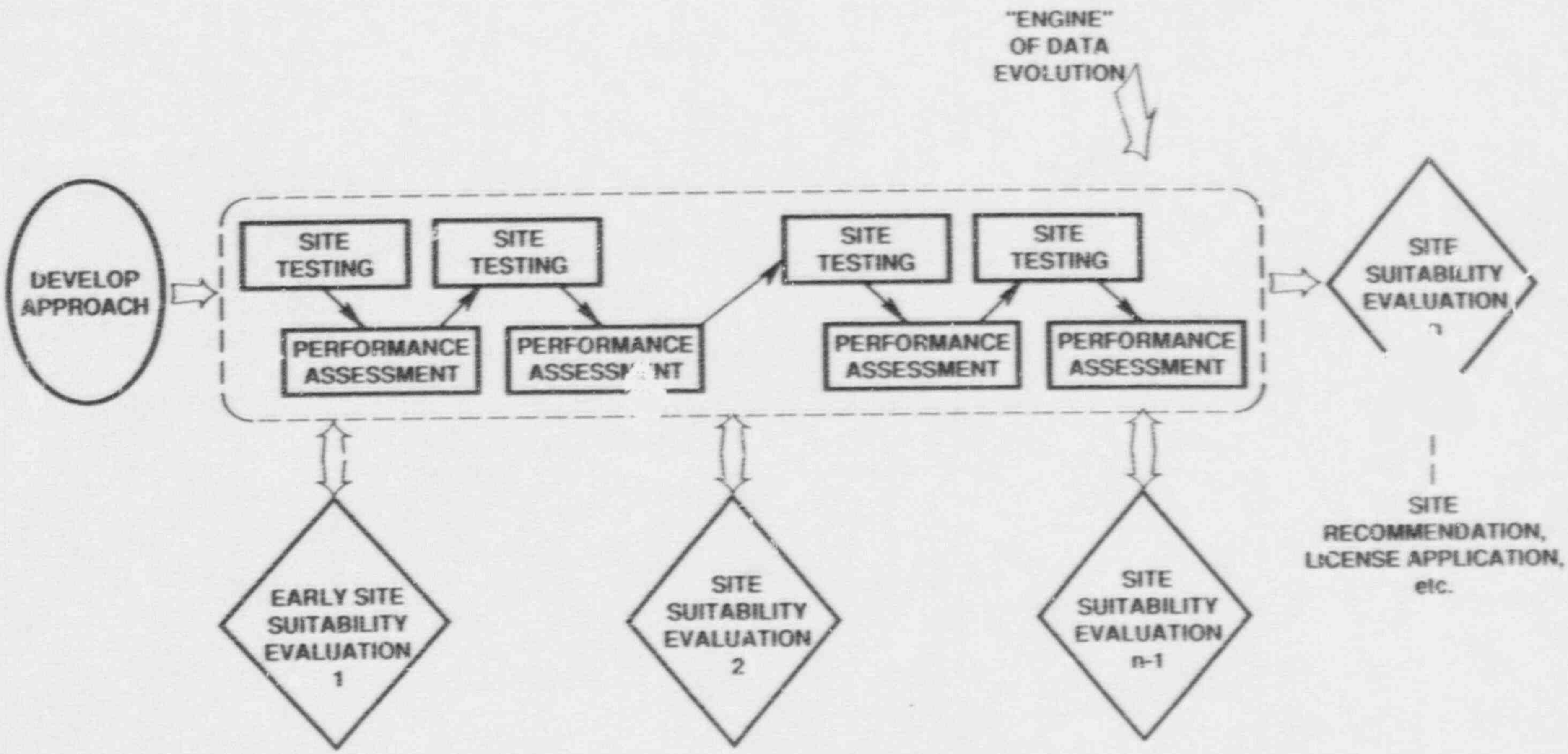
- BACKGROUND: 10 CFR PART 960, SITE CHARACTERIZATION & SITE SUITABILITY
- PLAN TO RE-EVALUATE 10 CFR PART 960 DISQUALIFYING CONDITIONS
- PERFORMANCE ASSESSMENT SUPPORT TO EVALUATION OF SUITABILITY AND ITERATIVE PRIORITIZATION OF SITE TESTING
- STATUS OF TEST PRIORITIZATION TASK

PERFORMANCE ASSESSMENT SUPPORT TO EVALUATION OF SITE SUITABILITY AND ITERATIVE PRIORITIZATION OF SITE TESTING

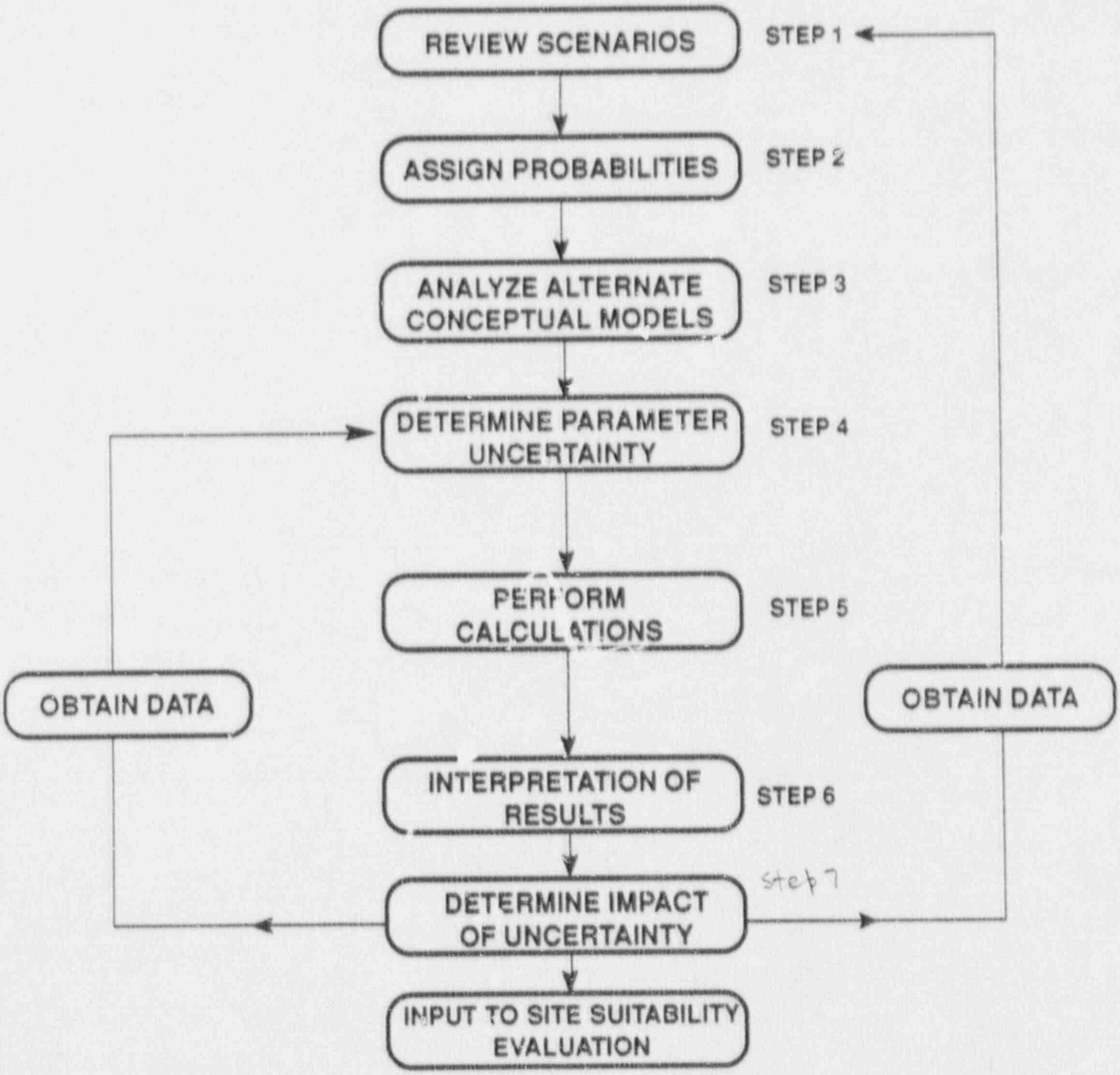
- SUPPORT DEVELOPMENT OF SUITABILITY MEASURES AND CRITERIA FOR SITE SUITABILITY EVALUATIONS

- PROVIDE INPUT TO FOCUS SITE CHARACTERIZATION PROGRAM

SCHEMATIC OF SITE SUITABILITY EVALUATION PROCESS



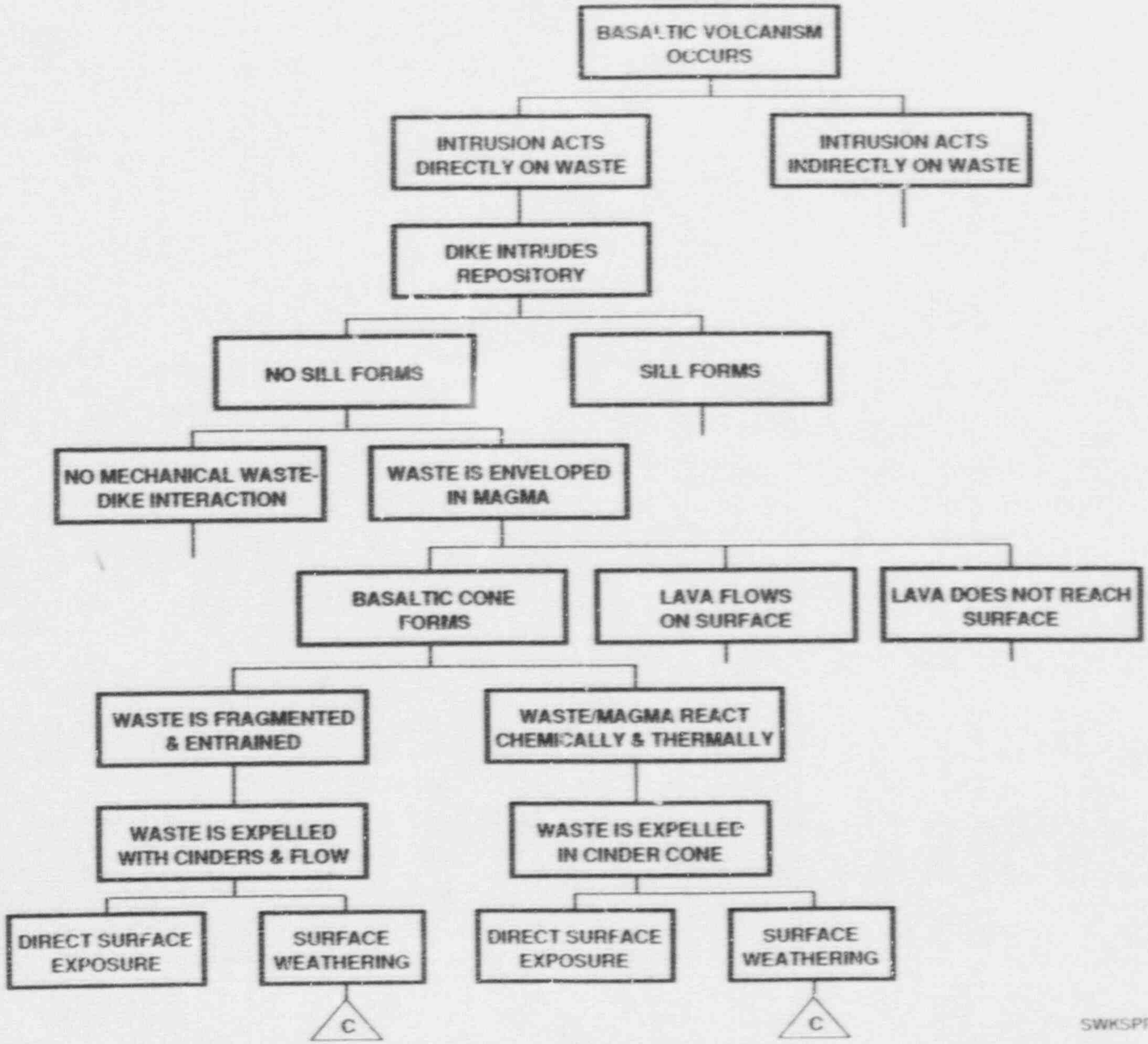
APPLYING PERFORMANCE ASSESSMENT FORMALISM TO SITE SUITABILITY



STEP 1: SCENARIO SCREENING

- USE OF EVENT TREES TO IDENTIFY FEATURES, EVENTS, PROCESSES LEADING TO CONDITIONS OF UNSUITABILITY
  - NOMINAL CASE INCLUDING CLIMATE CHANGE
  - BASALTIC VOLCANISM
  - HUMAN INTRUSION
  - TECTONISM
- DEVELOPMENT OF SCENARIOS COMBINING FEATURES, EVENTS AND PROCESSES – EMPHASIZE UNSUITABILITY CONDITIONS
- EMPHASIS ON HIGH CONSEQUENCE AND SIGNIFICANT PROBABILITY EVENTS

STEP 1: SCENARIO SCREENING



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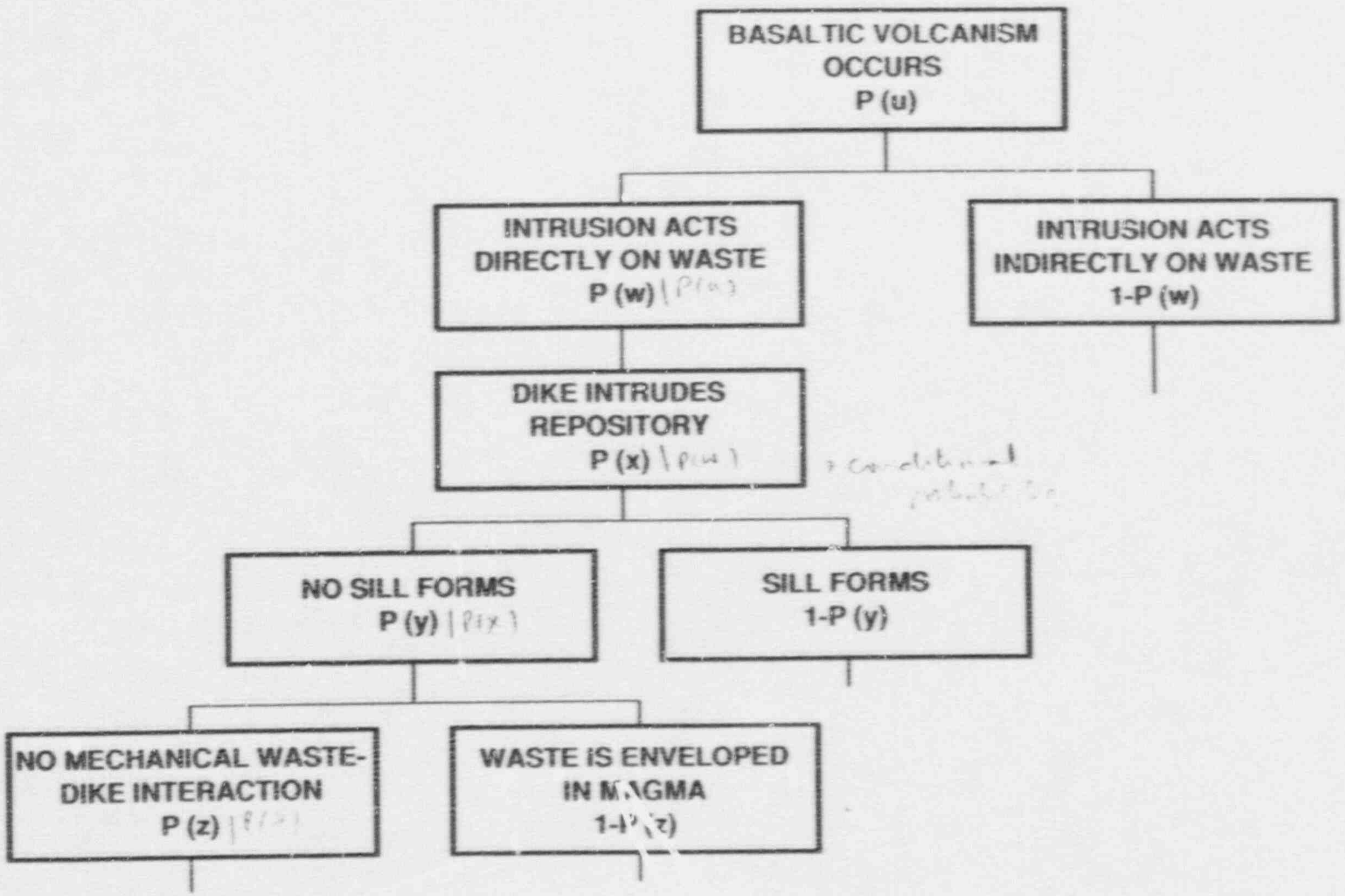
STEP 2: PROBABILITY ESTIMATION

- ASSIGN PROBABILITIES TO FEATURES, EVENTS, AND PROCESSES
  - EXPERT JUDGMENT
  - ANALYSIS
  - PUBLISHED RESULTS (SCP, EA)

STEP 2: PROBABILITY ESTIMATION

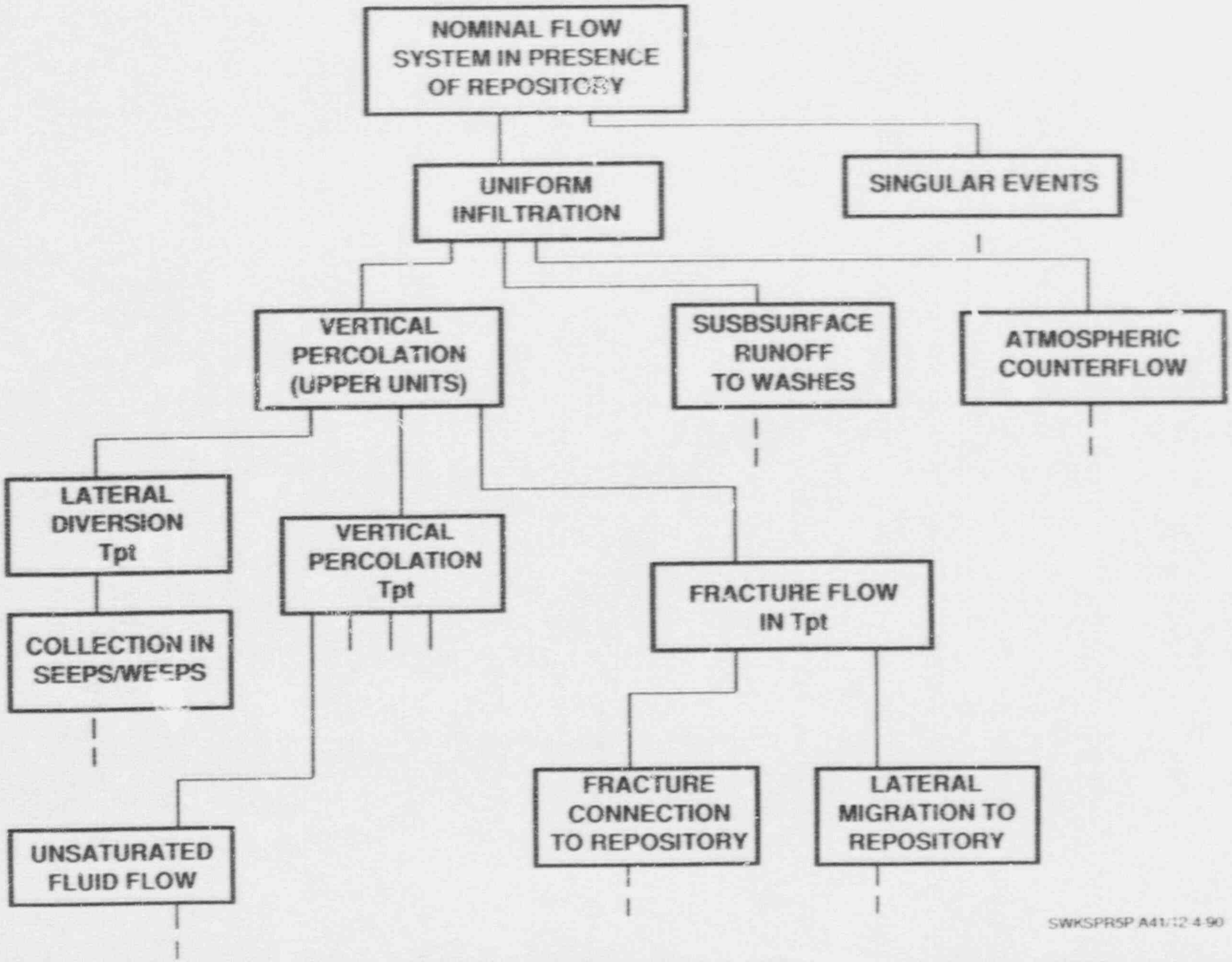


STEP 3: CONCEPTUAL MODEL APPLICATION

- IDENTIFY CONCEPTUAL MODELS

- FORMULATE PROBLEM DEFINITIONS (SCENARIOS) FROM EVENT TREES

ALTERNATIVE CONCEPTUAL MODELS FOR A NOMINAL CASE



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STEP 4: QUANTIFICATION OF PARAMETER UNCERTAINTY

- LARGE UNCERTAINTIES ASSOCIATED WITH OUR KNOWLEDGE OF PHYSICAL PROPERTIES AND BEHAVIOR
- PARAMETERS EXPRESSED AS DISTRIBUTIONS USING PRESCRIBED METHODS
- DISTRIBUTIONS WILL QUANTIFY OUR UNCERTAINTY

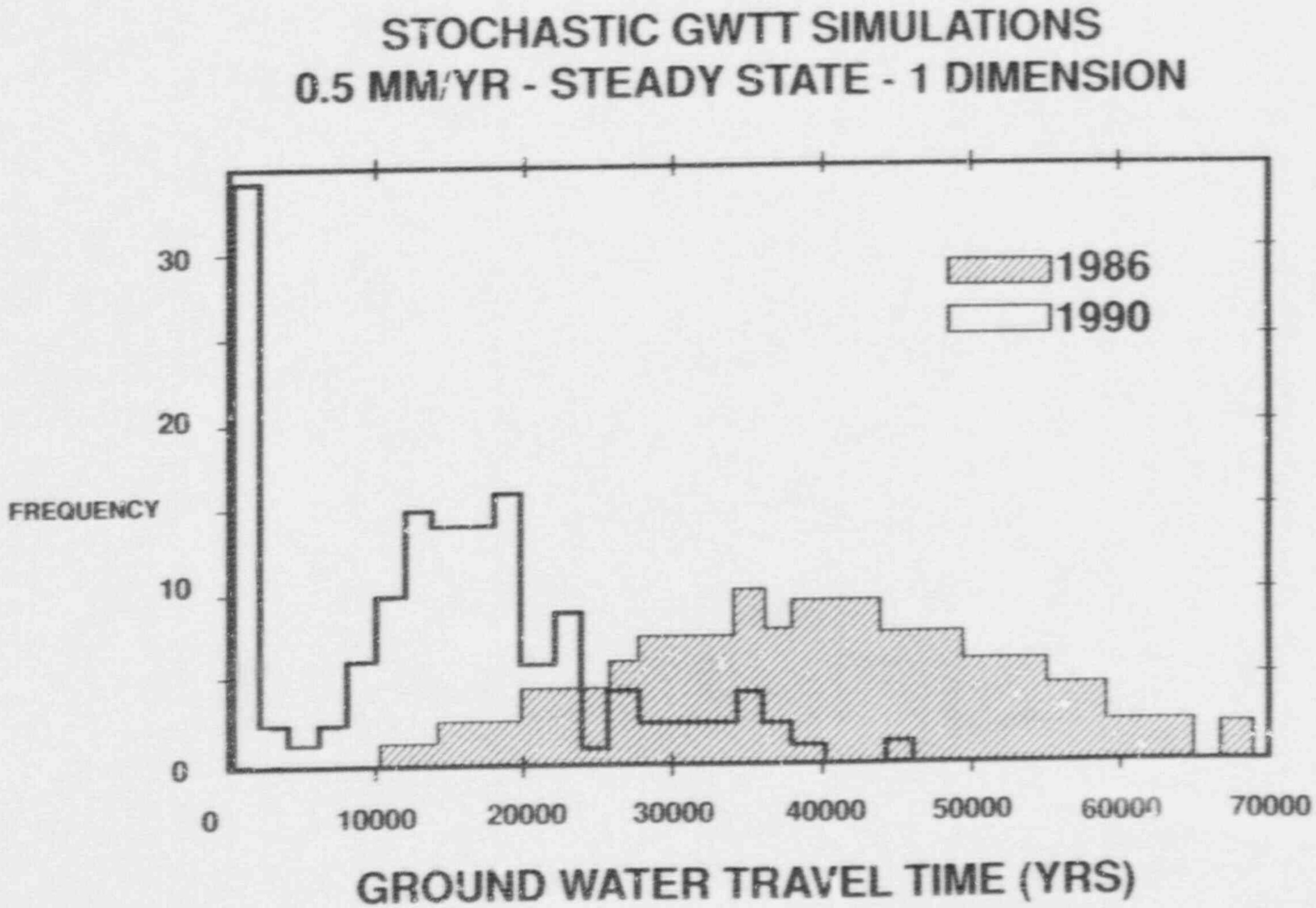
STEP 5: CALCULATIONS

- CALCULATIONS WILL RESULT IN DISTRIBUTIONS OF OUTCOMES
- MULTIPLE RUNS TO EVALUATE EFFECTS OF PARAMETER AND MODEL UNCERTAINTY
- EXPLICITLY STATE MODEL LIMITATIONS AND ASSUMPTIONS REGARDING INITIAL AND BOUNDARY CONDITIONS

STEP 6: INTERPRETATION OF RESULTS

- IDENTIFY PARAMETERS OF SIGNIFICANCE AND ASSOCIATED UNCERTAINTIES
- IDENTIFY CONDITIONS WITH ASSOCIATED UNCERTAINTIES THAT MAY RESULT IN UNSUITABILITY
- FORMULATE/REFINE SUITABILITY MEASURES AND CRITERIA

STEP 5-6: CALCULATIONS AND INTERPRETATION



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SUITABILITY MEASURES

- SUITABILITY MEASURES WILL BE EXPRESSED IN TERMS OF OUR UNCERTAINTIES IN INPUTS AND MODELS
- SUITABILITY MEASURES WILL BE MODIFIED OR DEFINED USING ANALYTICAL RESULTS WITH EXPERT JUDGMENT
- SUITABILITY MEASURES MAY BE BASED ON RELEASES TO THE ACCESSIBLE ENVIRONMENT

CONCLUSIONS

- PERFORMANCE ASSESSMENT METHODS WILL BE USED TO SUPPORT SITE SUITABILITY EVALUATIONS
- SUITABILITY MEASURES AND CRITERIA WILL BE DEVELOPED OR MODIFIED ON THE BASIS OF PERFORMANCE ASSESSMENT CALCULATIONS
- ANALYSES WILL PROVIDE INPUT TO TEST PRIORITIZATION
- THIS APPROACH WILL EVOLVE TO INCORPORATE DETAILS OF THE ENGINEERED BARRIER SYSTEM AS THE SUITABILITY PROCESS CONTINUES

OVERVIEW OF DOE'S ACTIVITIES TO FOCUS TESTING PROGRAM ON SITE SUITABILITY

J. R. DYER
YUCCA MOUNTAIN PROJECT OFFICE
LAS VEGAS, NV

EPRI PERFORMANCE ASSESSMENT WORKSHOP
DECEMBER 4-6, 1990
WASHINGTON, D.C.

SUMMARY OF DOE PRESENTATIONS

- BACKGROUND: 10 CFR PART 960, SITE CHARACTERIZATION & SITE SUITABILITY
- PLAN TO RE-EVALUATE 10 CFR PART 960 DISQUALIFYING CONDITIONS J. Younker & Rickertson
- PERFORMANCE ASSESSMENT SUPPORT TO EVALUATION OF SUITABILITY AND ITERATIVE PRIORITIZATION OF SITE TESTING A. Dochanne
- STATUS OF TEST PRIORITIZATION TASK

STATUS OF SITING GUIDELINES

- DOE HAS MADE A COMMITMENT TO EARLY EVALUATION OF SITE SUITABILITY

- THE SITING GUIDELINES (10 CFR PART 960) ARE APPLICABLE TO THE EVALUATION OF A SINGLE SITE

APPLICABILITY OF SITING GUIDELINES

- 10 CFR PART 960 (THE SITING GUIDELINES) SPECIFIES THE GENERALLY APPLICABLE CONSIDERATIONS MANDATED IN SECTION 112(a) OF THE NUCLEAR WASTE POLICY ACT OF 1982 (NWPA) FOR THE EVALUATION OF SUITABILITY OF POTENTIAL REPOSITORY SITES
  - THE NWPAA OF 1987 SPECIFIED YUCCA MOUNTAIN AS THE SINGLE SITE FOR CHARACTERIZATION

USE OF SITING GUIDELINES IN EARLY EVALUATION OF SITE SUITABILITY

- IN ORDER TO COMPLY WITH THE NWPA, THE NWPAA, 10 CFR PART 960, AND MEET THE SECRETARY'S COMMITMENT TO AN EARLY EVALUATION OF SITE SUITABILITY, TWO KINDS OF EVALUATIONS ARE REQUIRED

  – A COMPREHENSIVE EVALUATION OF SUITABILITY PRIOR TO A DECISION ON RECOMMENDATION FOR DEVELOPMENT OF A SITE AS A REPOSITORY

  – EARLY AND ITERATIVE EVALUATIONS THAT FOCUS ON POTENTIAL DISQUALIFYING CONDITIONS

USE OF SITING GUIDELINES IN EARLY EVALUATION OF SITE SUITABILITY

- EARLY EVALUATION OF SITE SUITABILITY IS NOT ADDRESSED BY THE NWPA, NWPAA, OR THE SITING GUIDELINES

- THE ONLY GUIDANCE FOR EARLY EVALUATIONS IS FOUND IN 10 CFR 960.3–1–5, WHICH REQUIRES CONSIDERATION OF THE DISQUALIFYING AND QUALIFYING CONDITIONS

  – "A SITE SHALL BE DISQUALIFIED AT ANY TIME DURING THE SITING PROCESS IF THE EVIDENCE SUPPORTS A FINDING BY THE DOE THAT A DISQUALIFYING CONDITION EXISTS OR THE QUALIFYING CONDITION OF ANY SYSTEM OR TECHNICAL GUIDELINE CANNOT BE MET."

USE OF SITING GUIDELINES IN EARLY EVALUATION OF SITE SUITABILITY

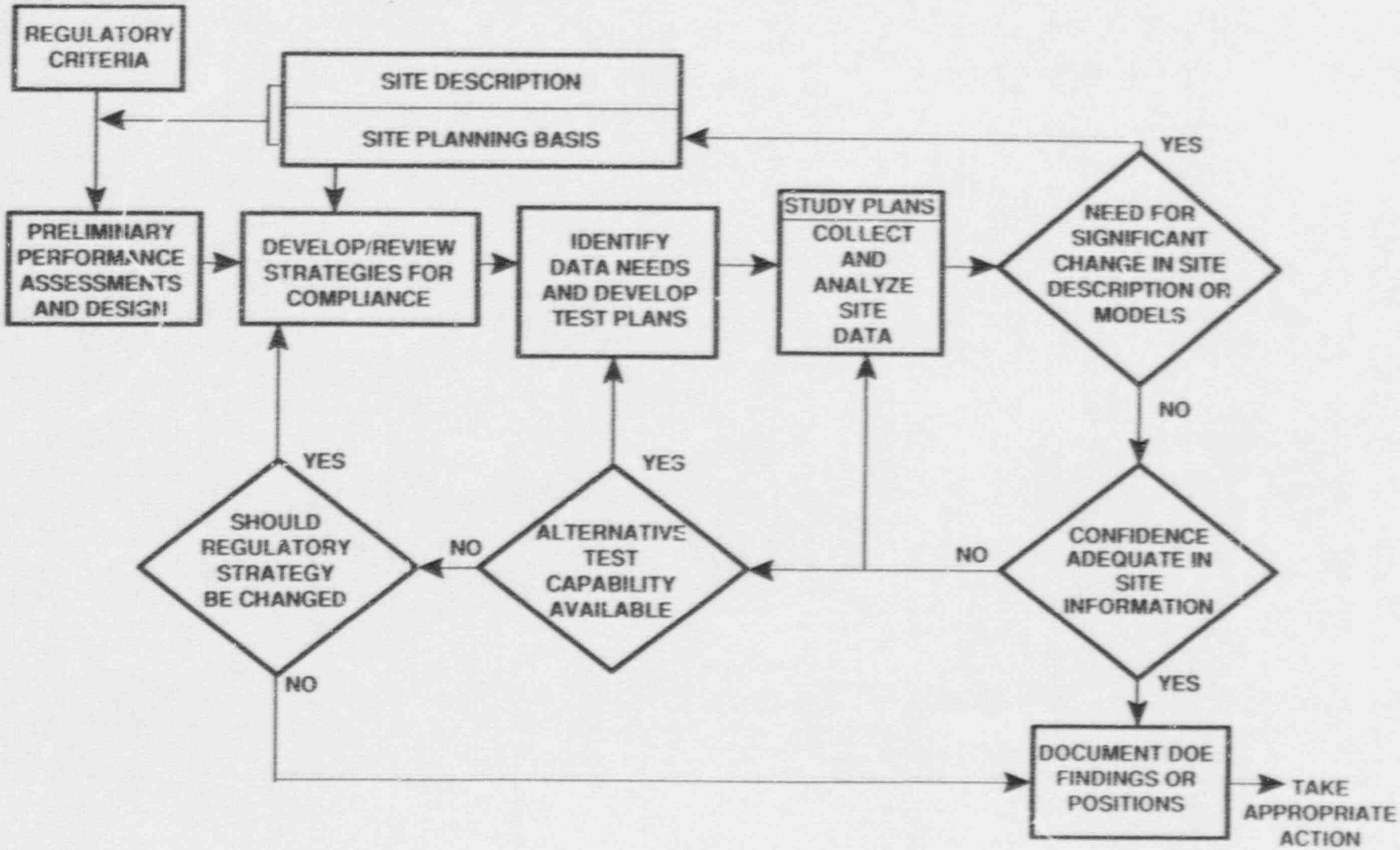
THE DISQUALIFYING CONDITIONS OF
10 CFR PART 960:

- PLACE A LESSER RELIANCE ON COMPREHENSIVE PERFORMANCE ASSESSMENTS THAN THE QUALIFYING CONDITIONS

- ARE RELATED TO EXPRESSED CONCERNS ON THE SUITABILITY OF ANY SITE

- AND, CONSEQUENTLY, MAY BE MORE USEFUL FOR IMPLEMENTING AN EARLY EVALUATION OF UNSUITABILITY

LOGIC OF SITE CHARACTERIZATION PROGRAM



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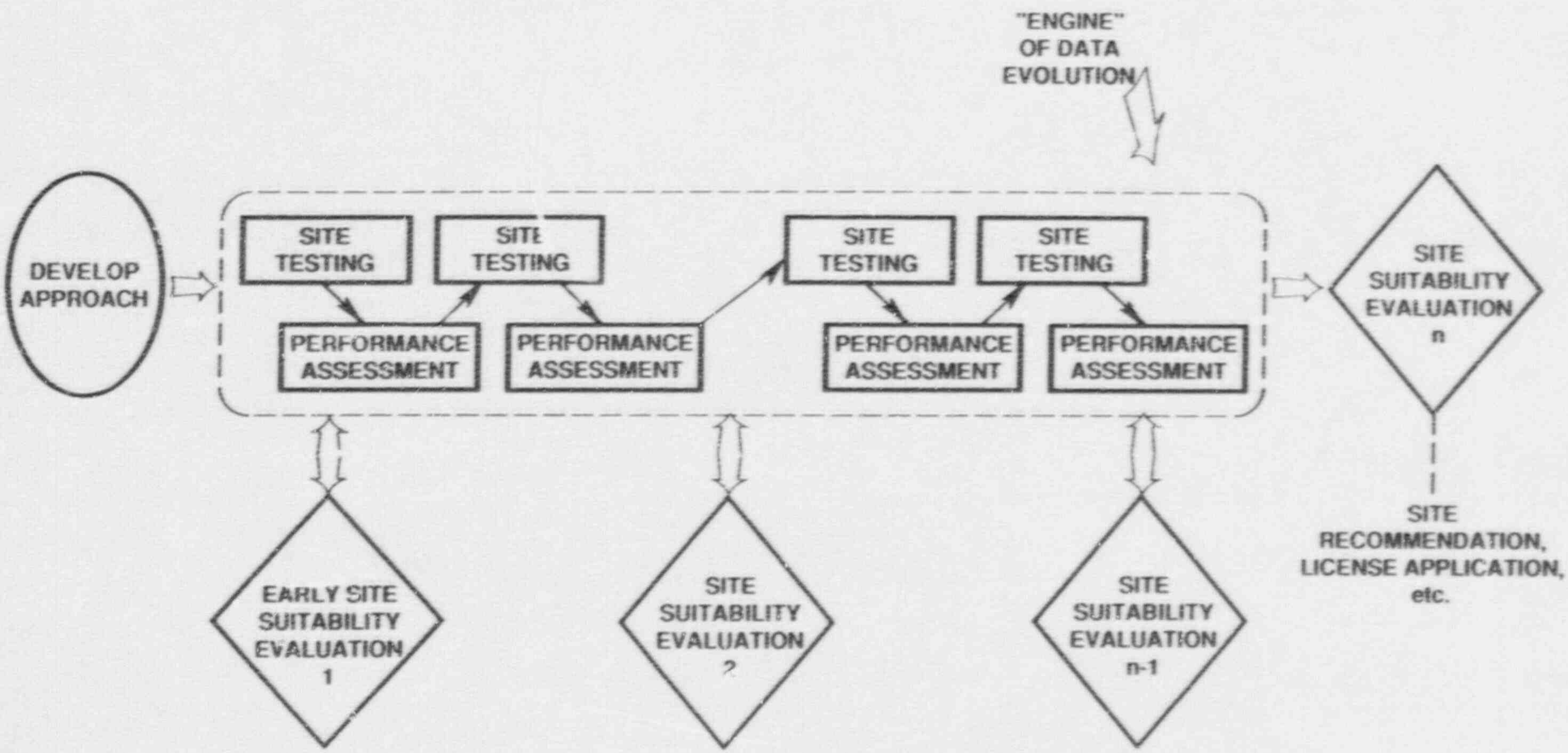
SCHEMATIC OF SITE SUITABILITY EVALUATION PROCESS

John Bartlett's slide



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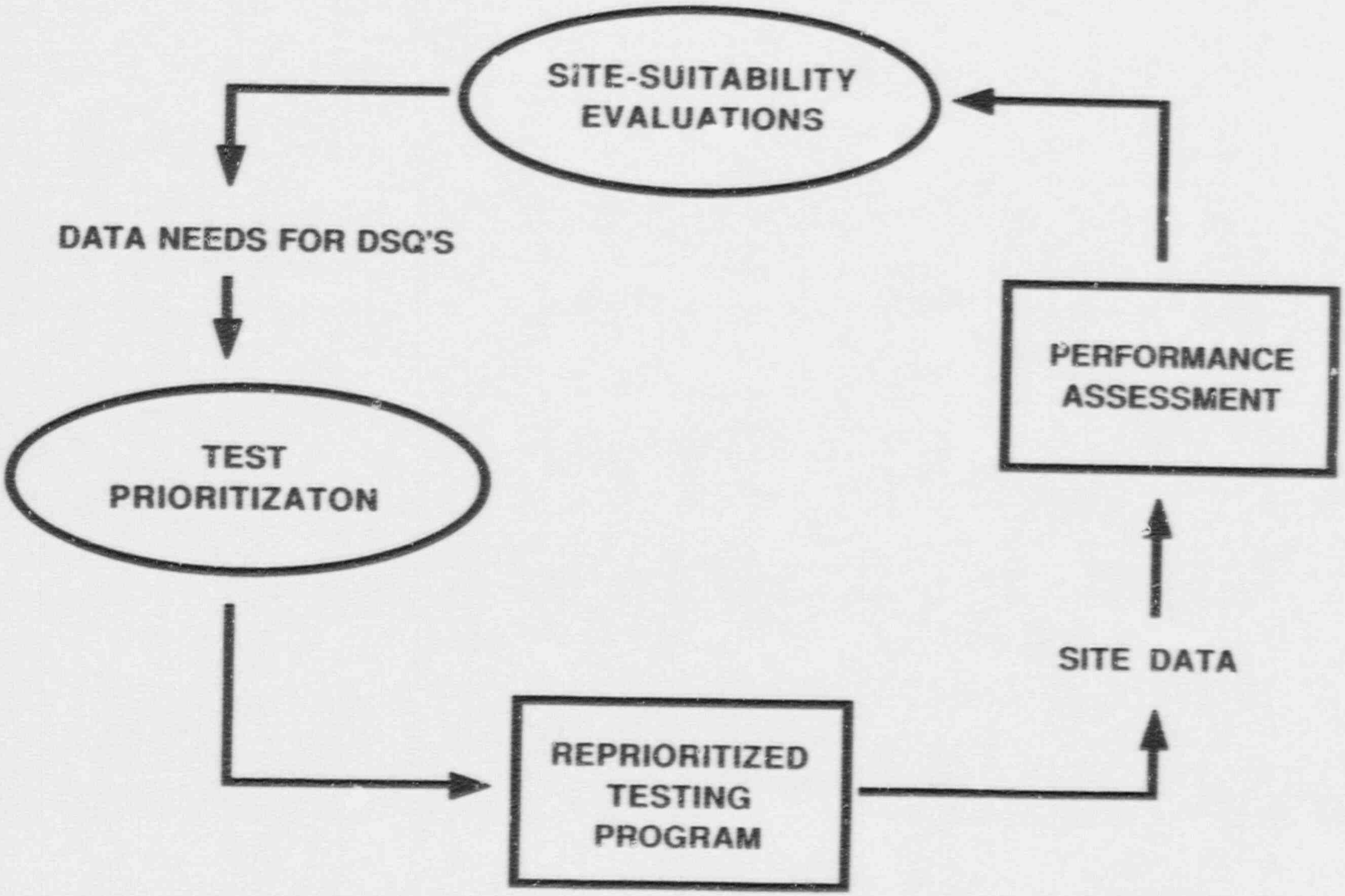
PHASE I
TEST PRIORITIZATION FOR SITE-SUITABILITY



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OVERVIEW OF DOE'S ACTIVITIES TO FOCUS TESTING PROGRAM ON SITE SUITABILITY

B. JUDD
DECISION ANALYSIS COMPANY
PALO ALTO, CA

EPRI PERFORMANCE ASSESSMENT WORKSHOP
DECEMBER 4-6, 1990
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Agenda

- Task overview
  - Test prioritization objectives
  - Task force participants
  - Phased approach and schedule

- Summary of the decision analysis approach
  - Focus on tests that affect early decisions
  - Decision criterion
  - Example analysis: gas-phase release

- Phase 1 application
  - Assessing the importance of potential concerns
  - Assessing the accuracy of testing
  - Prioritizing tests

- Summary and plan for Phase 2

This study was initiated to help DOE refocus near-term testing on early detection of any unsuitable conditions

- The DOE Secretary's review of the OCRWM program produced a directive to refocus near-term site testing

- DOE reported its plan to Congress in Nov. '89

  "DOE has decided to focus its near-term scientific investigations ... specifically at evaluating whether the site has any feature that would indicate that it is not suitable as a potential repository site."

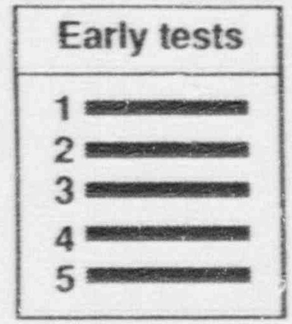
  Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program

DOE has two primary objectives for this task

Objectives

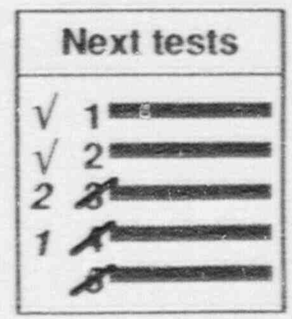
- Develop an explicit decision analysis method to prioritize testing in the initial phase of site investigation

  Ensure early investigation of significant, potentially adverse conditions and other concerns



- Recommend methods to re-prioritize testing at any point during site characterization

  Include a method for deciding when to stop testing

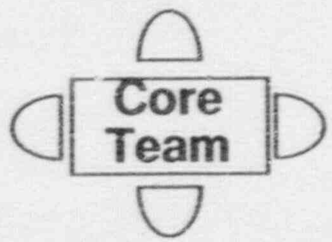


The method should be consistent with site-suitability evaluation methods

A core team was assembled to conduct analyses and make recommendations to management

Steven Mattson
SAIC, team lead

Dwight T. Hoxie
USGS

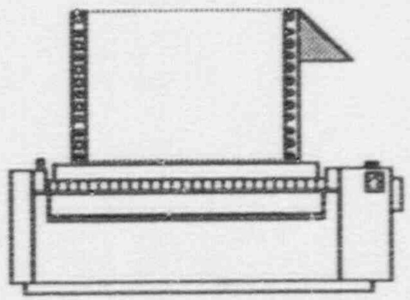


Scott Sinnock
Sandia

Bruce Judd
(Decision Analysis Co.)

J. Russell Dyer
(DOE/YMP oversight and management)

Quantitative inputs to the analysis are based on prior site data and expert judgments



Existing site data

- **Data bases**
- **Prior studies**

Expert judgments from technical experts

- **LANL, LBL, LLNL, ORNL, PNL**
- **SAIC, SNL, UCB, USGS, Weston**
- **consultants, etc.**
- **DOE (oversight)**

Over 70 technical experts have participated to date

A two-phased approach has been developed to assist calendar-year 1991 and 1992 test prioritizations

Phases | **Target Dates**

1. "Spreadsheet" application

   Based on available information, expert assessments, judgments on test values and impacts

2. "Simple PA model" application

   Based on Phase 1 assessments plus simplified performance assessment model calculations plus assessments by a larger sampling of the experts

Agenda

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  - Assessing the accuracy of testing
  - Prioritizing tests

- Summary and plan for Phase 2

The task force will identify major tests that should be started early during site characterization

Illustrative Study Results

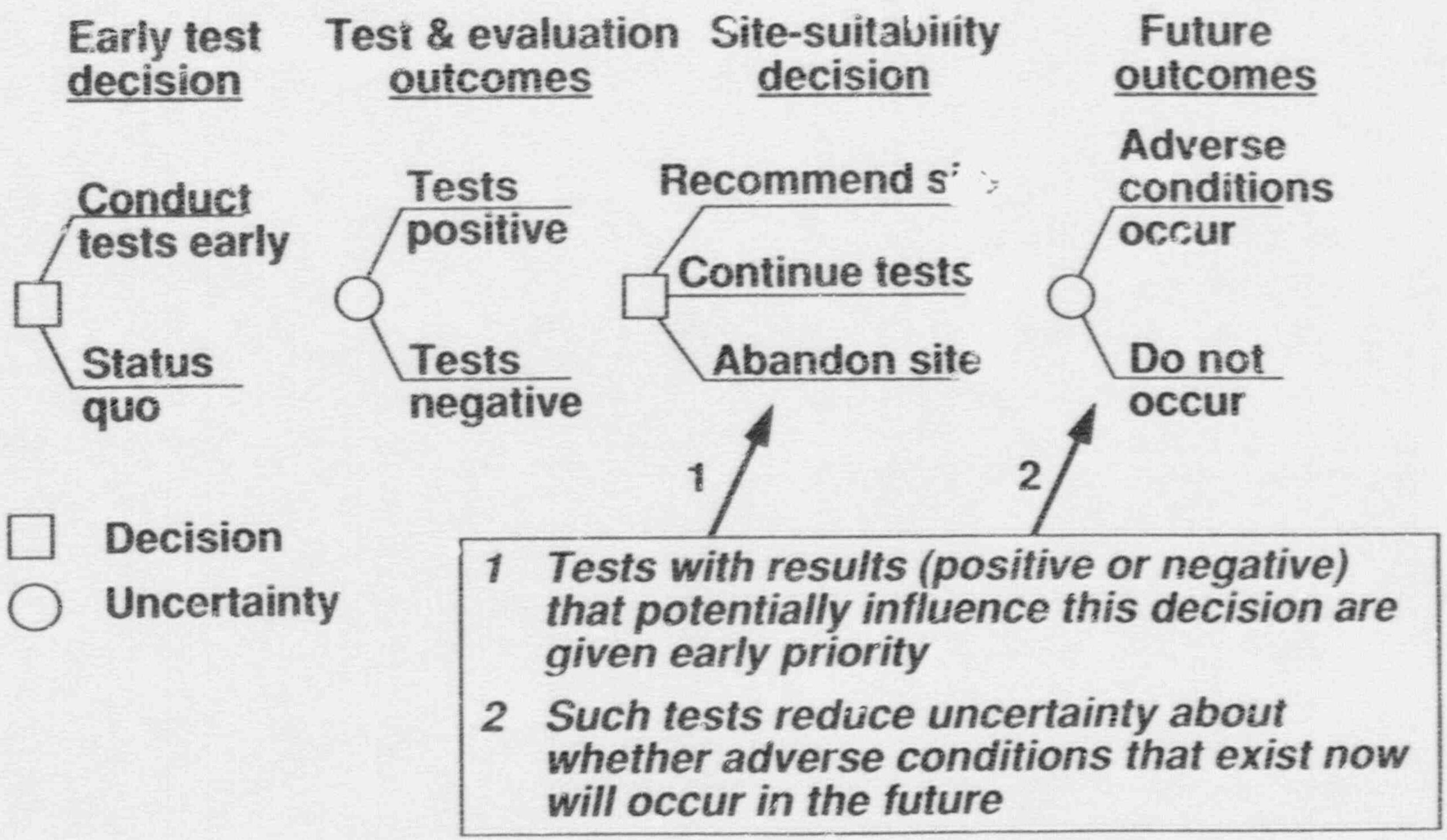
Priority	"Test"	Reason
1	Ground-water flow time in saturated zone	Parti[illegible] resolves uncertainty a[illegible]l time
1	Ground-water chemistry near repository	[illegible]y resolves uncertainty [illegible]out source term
2	Carbon-14 retardati[illegible]	May resolve uncertainty
2	Matrix vs. frac[illegible] UZ	May resolve uncertainty
3	Historical clima[illegible] change	Unlikely to resolve uncert.
3	...	...
3	...	...

Hypothetical results
(not based on analysis)

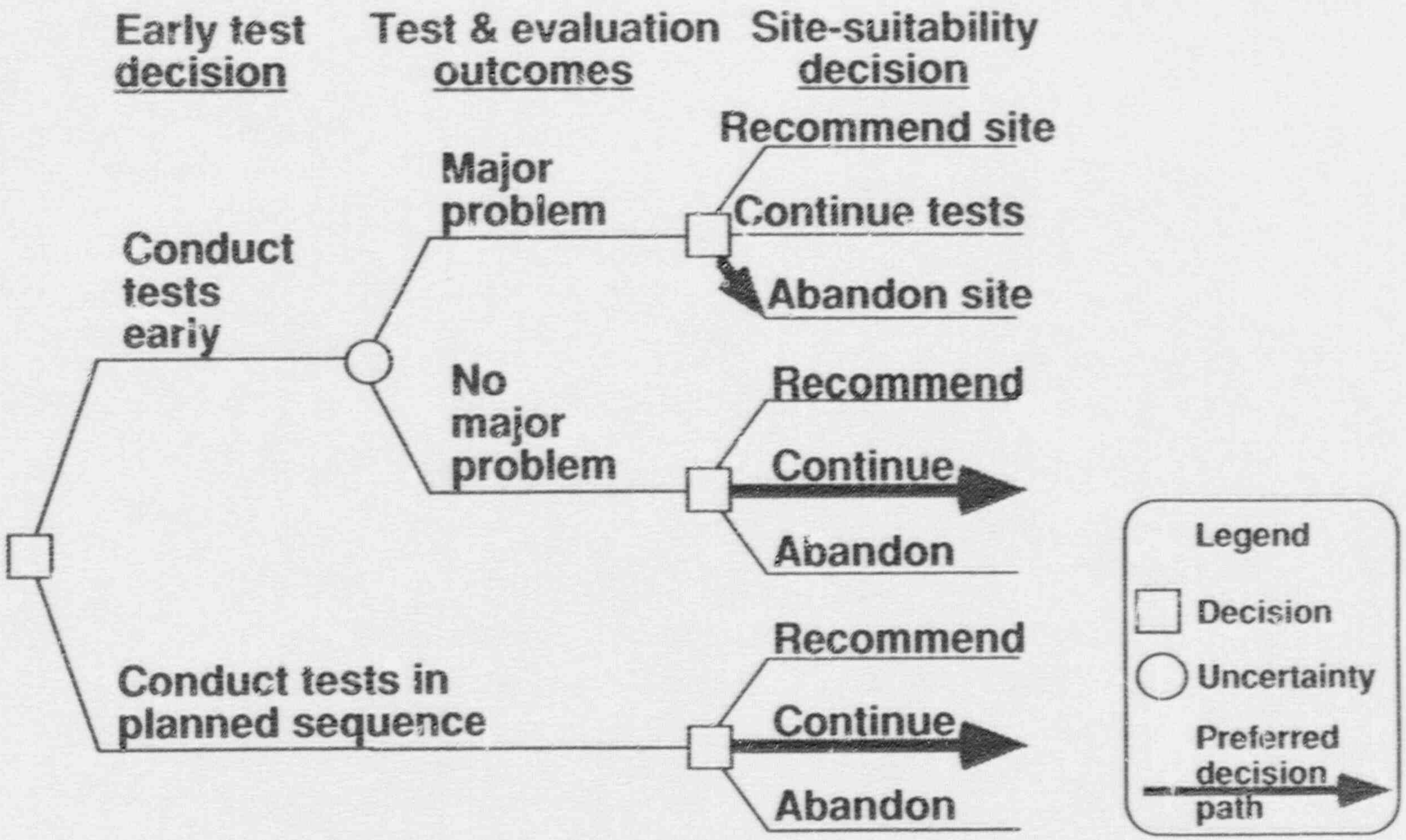
The term "test" refers to any group of SCP tests that provides information about an uncertain factor

The analysis identifies tests that significantly influence DOE decisions about site suitability

Simplified decision chronology



A simple decision tree shows how a test outcome might affect a decision about site suitability



Tests with outcomes that could change decisions are said to have positive "value-of-information"

Note: there may be *other reasons* for testing besides gathering information that could affect site decisions

Possible *other reasons* for testing

1. Facilitating other tests (e.g., drilling boreholes)
2. Initiating long-duration performance-confirmation tests
3. Gathering information for design or construction
4. Providing additional information required for licensing
5. Building scientific consensus and public confidence
6. ...

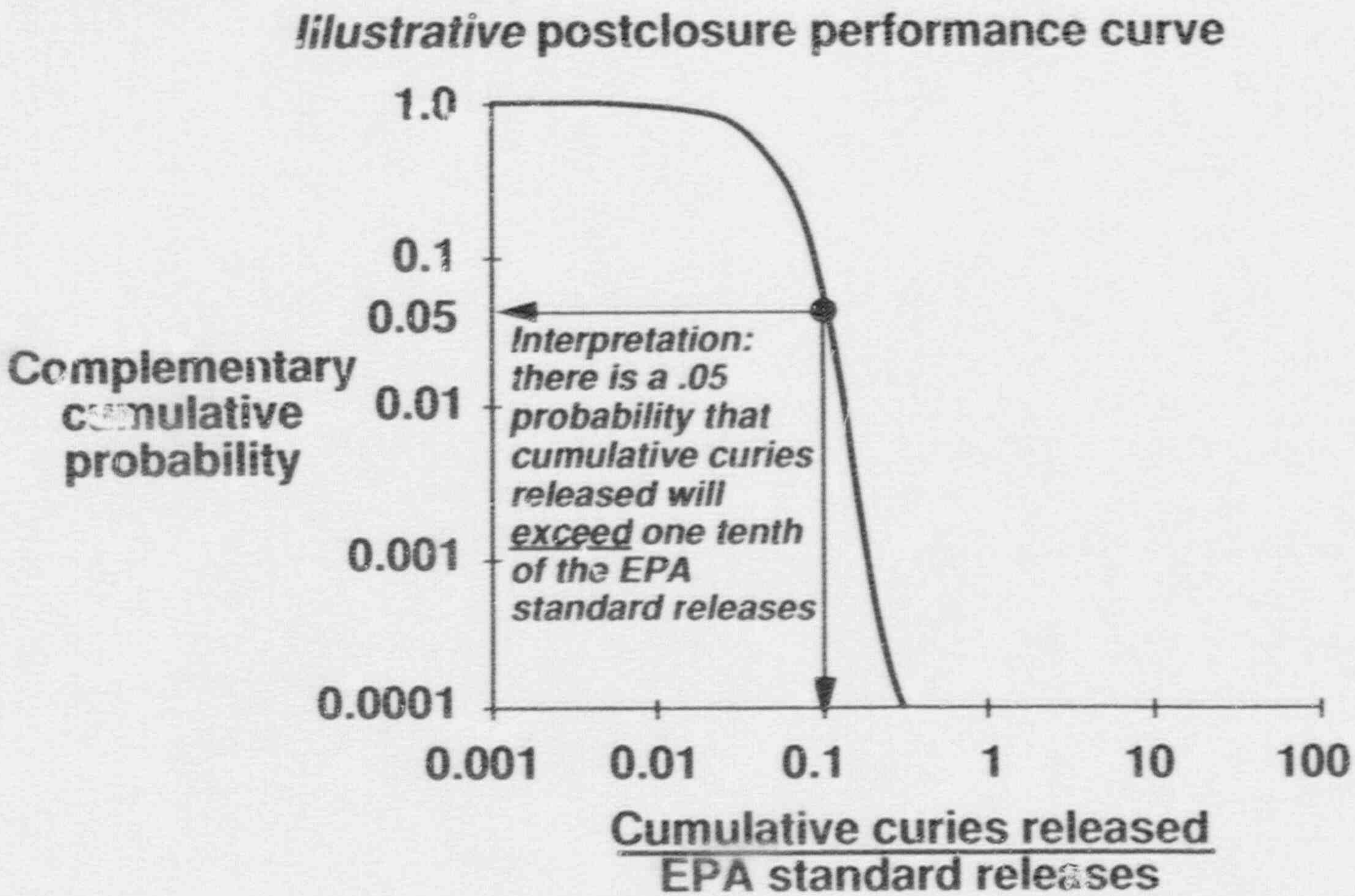
Priorities may need to be revised based on these considerations

A useful indicator of an unsuitable site is unacceptable pre- or postclosure performance of the total system

- In this first analysis, cumulative curies released over 10,000 years was used as a proxy for <u>all</u> applicable postclosure performance measures

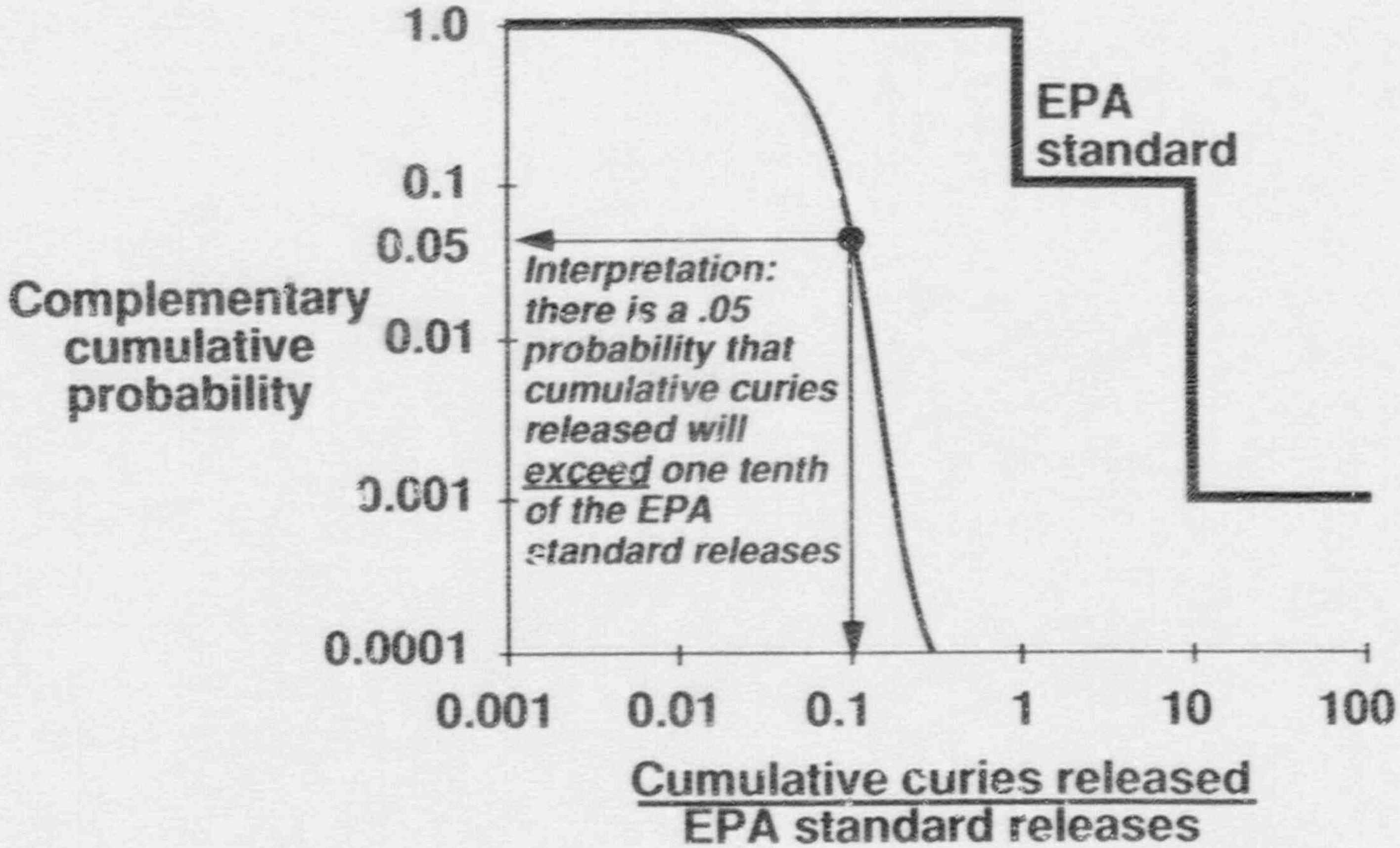
- Priorities may be modified to account for some tests not related strictly to total system performance

Uncertainty in postclosure performance is represented using a complementary cumulative probability distribution



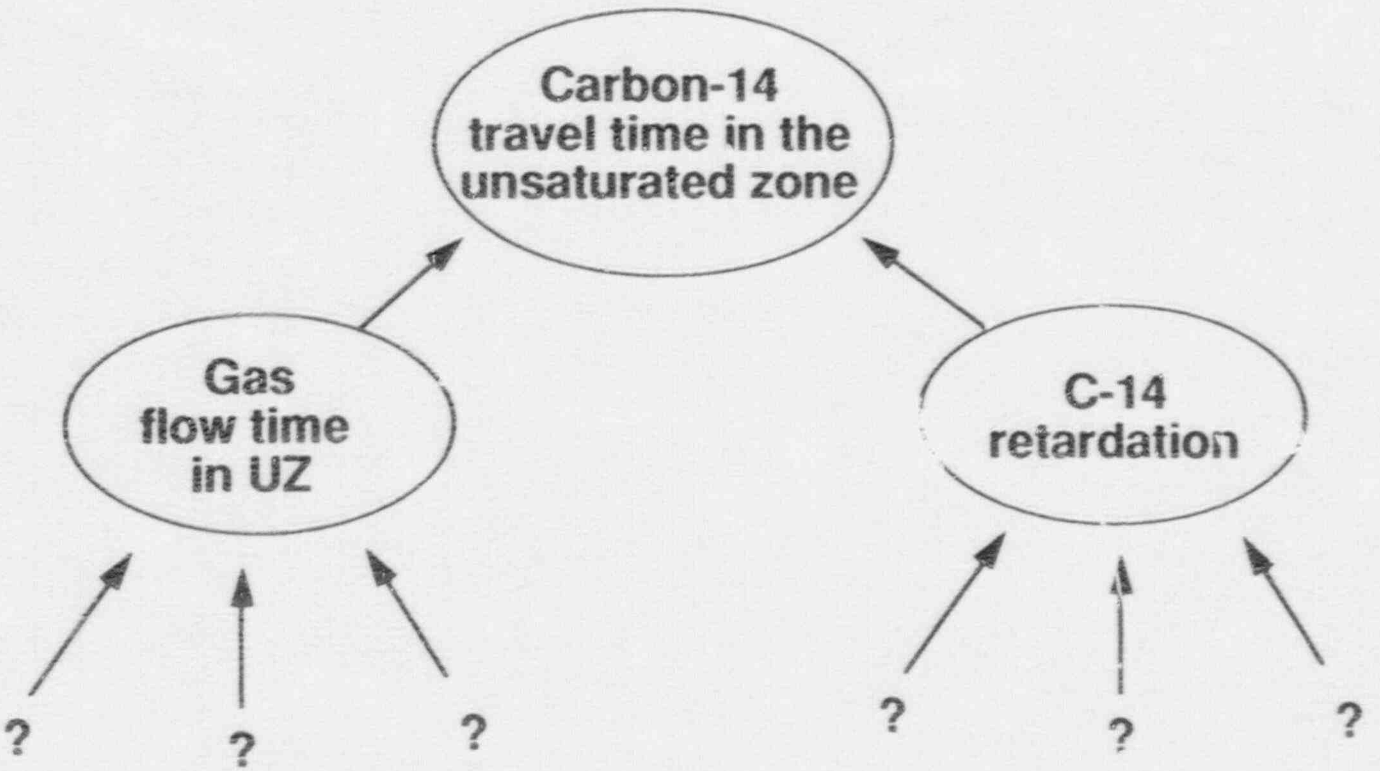
The expected value of this distribution can serve as a single-valued performance index

The "EPA standard" is one possible criterion for judging postclosure performance



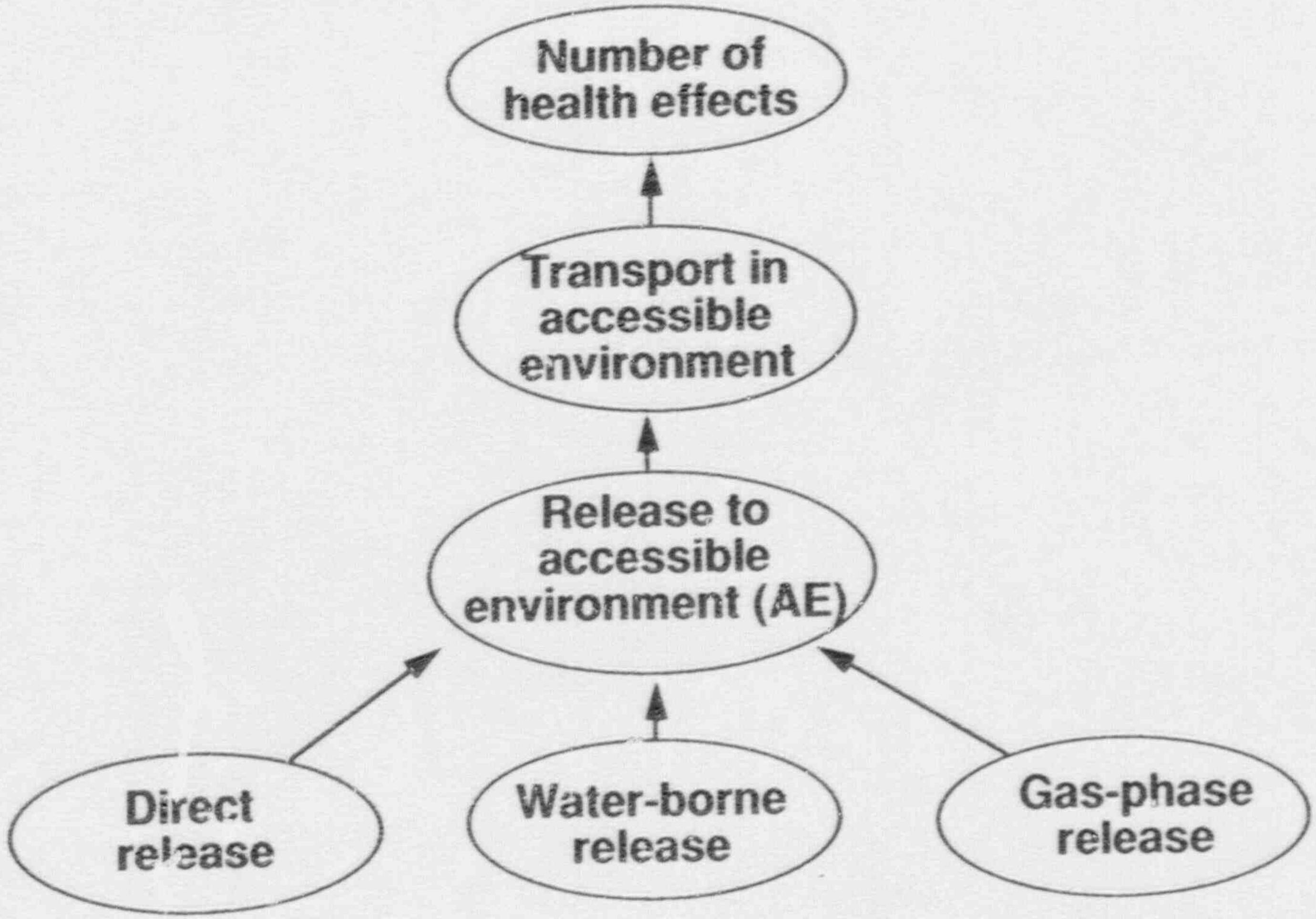
This is the criterion used in our analysis

"Influence diagrams" are used to identify key model parameters and probabilistic relationships

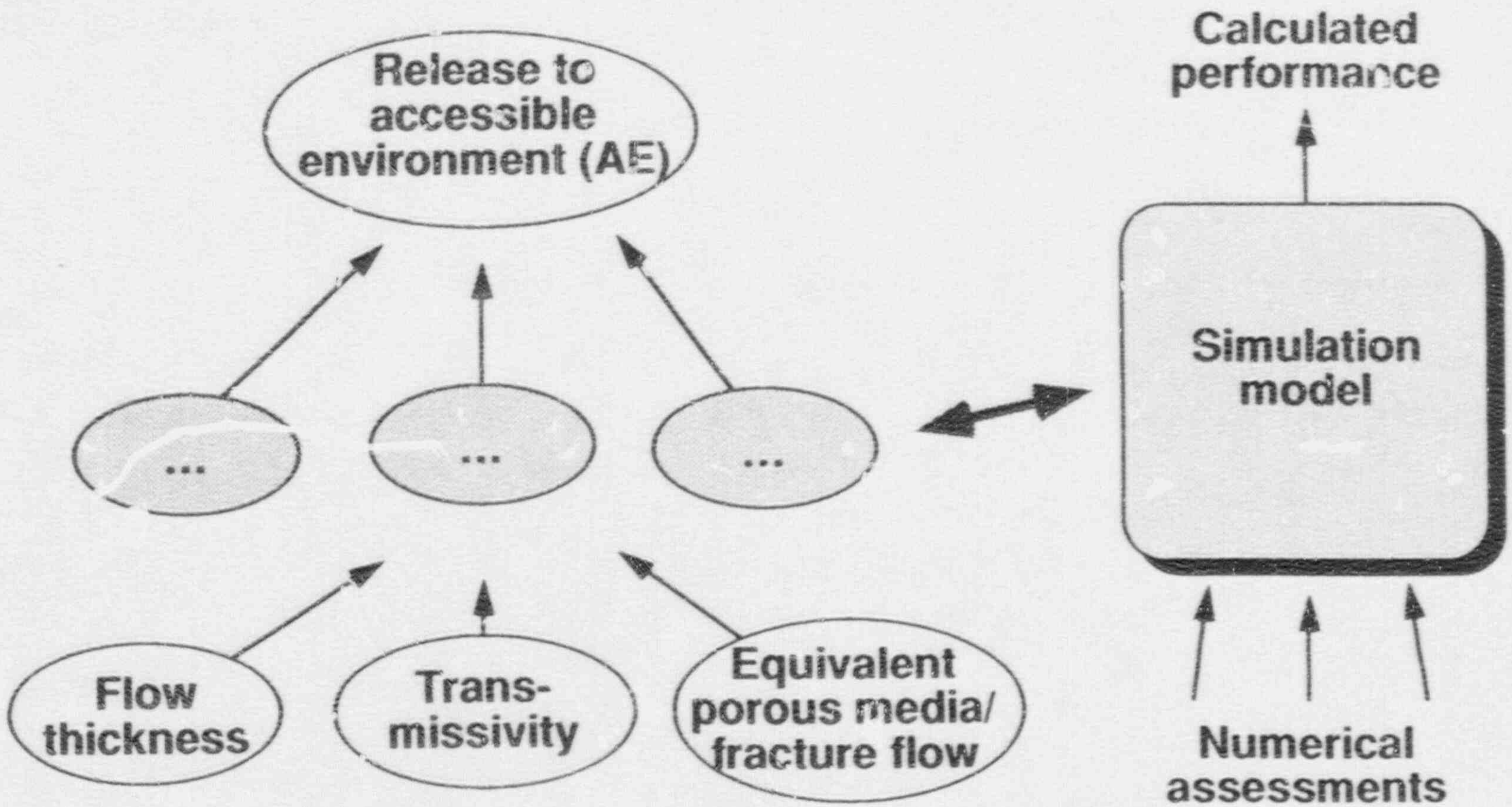


The diagrams are constructed from the top down.
The arrows have special meaning involving probabilistic dependence

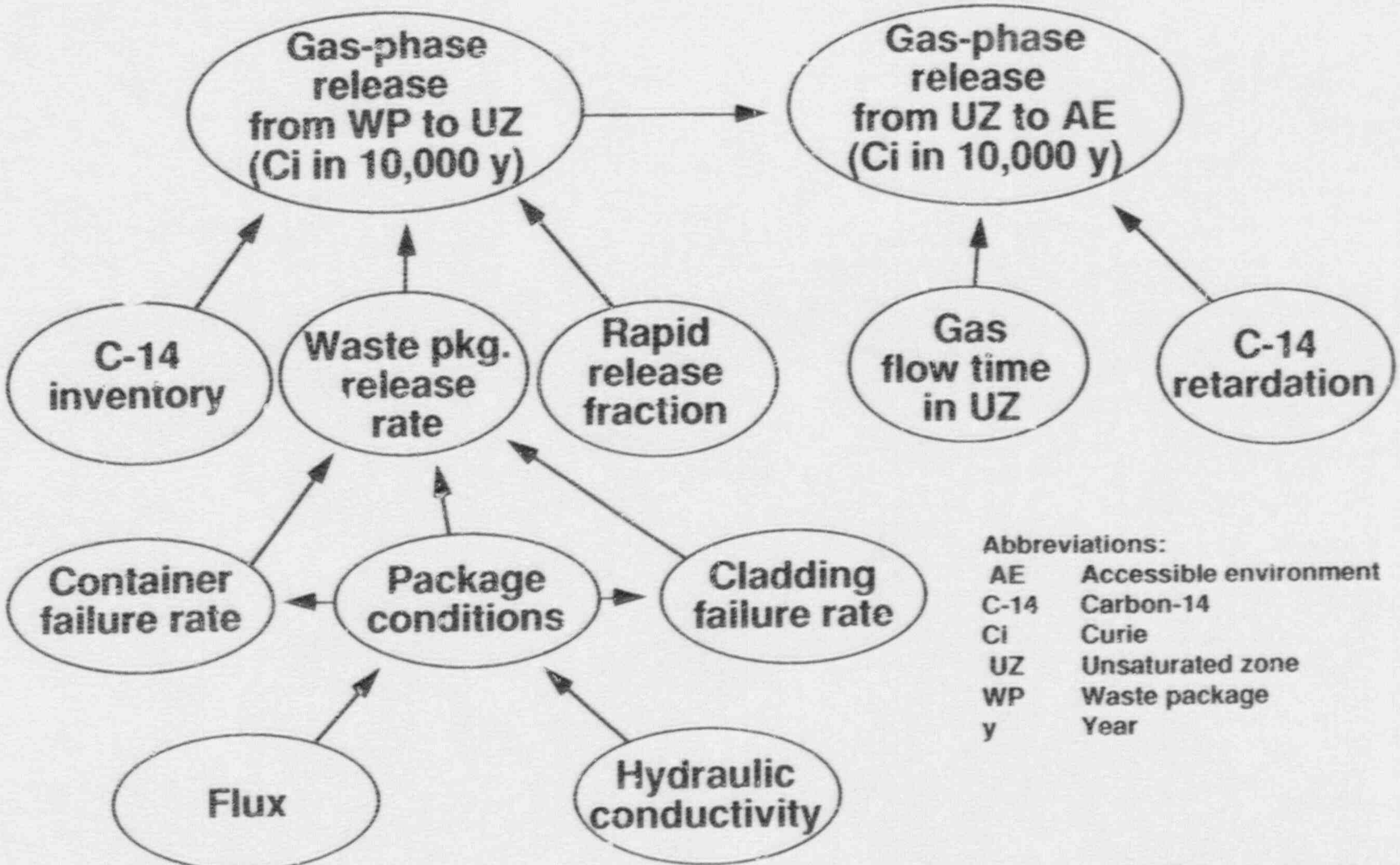
Common influence diagrams have been constructed for use in the Calico Hills, Exploratory Shaft Facility, and Test Prioritization task forces



A simplified model is used to calculate performance from assessments of key uncertainties



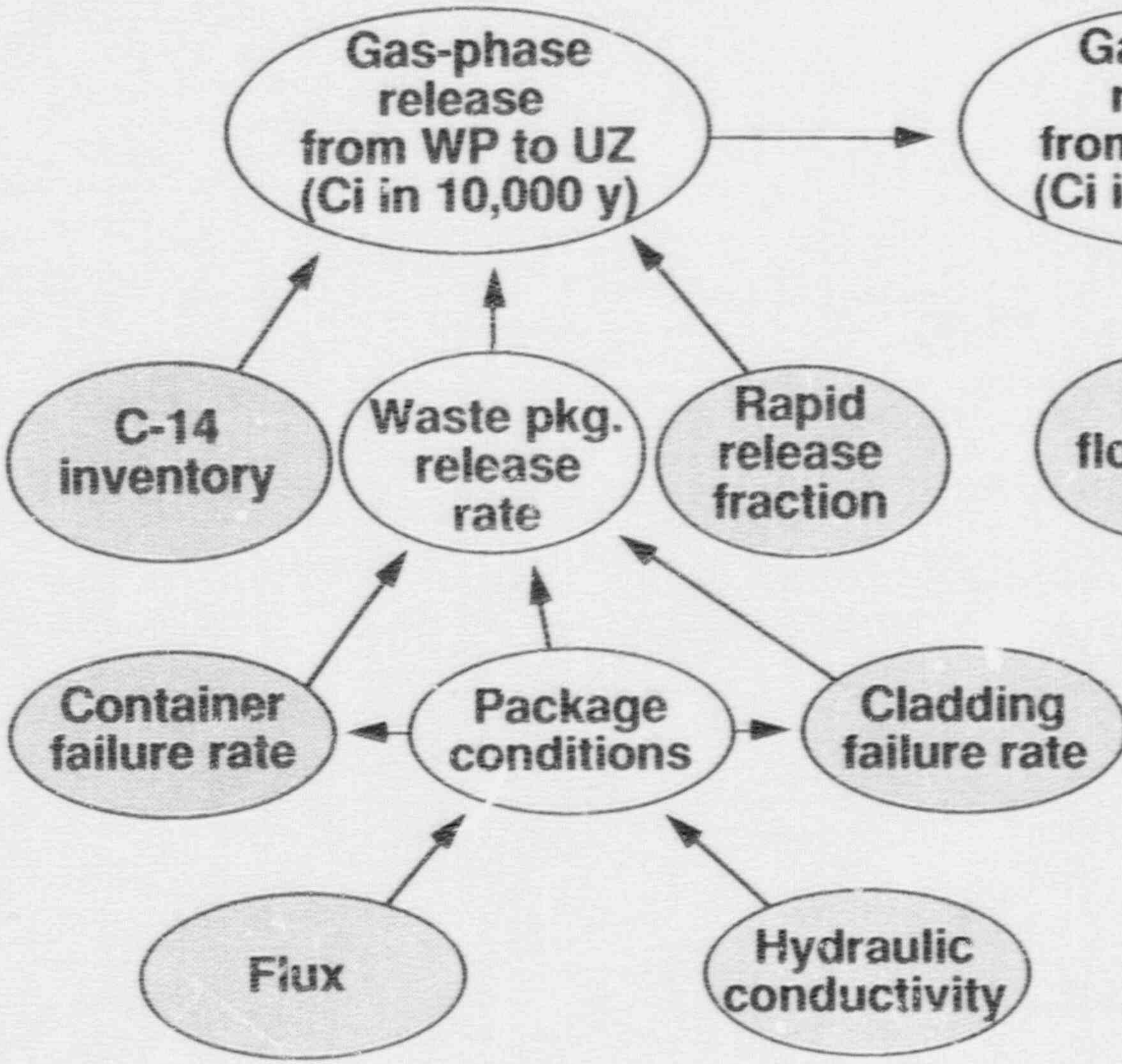
This influence diagram guided model development and data assessment for gas-phase releases



Abbreviations:

AE	Accessible environment
C-14	Carbon-14
Ci	Curie
UZ	Unsaturated zone
WP	Waste package
y	Year

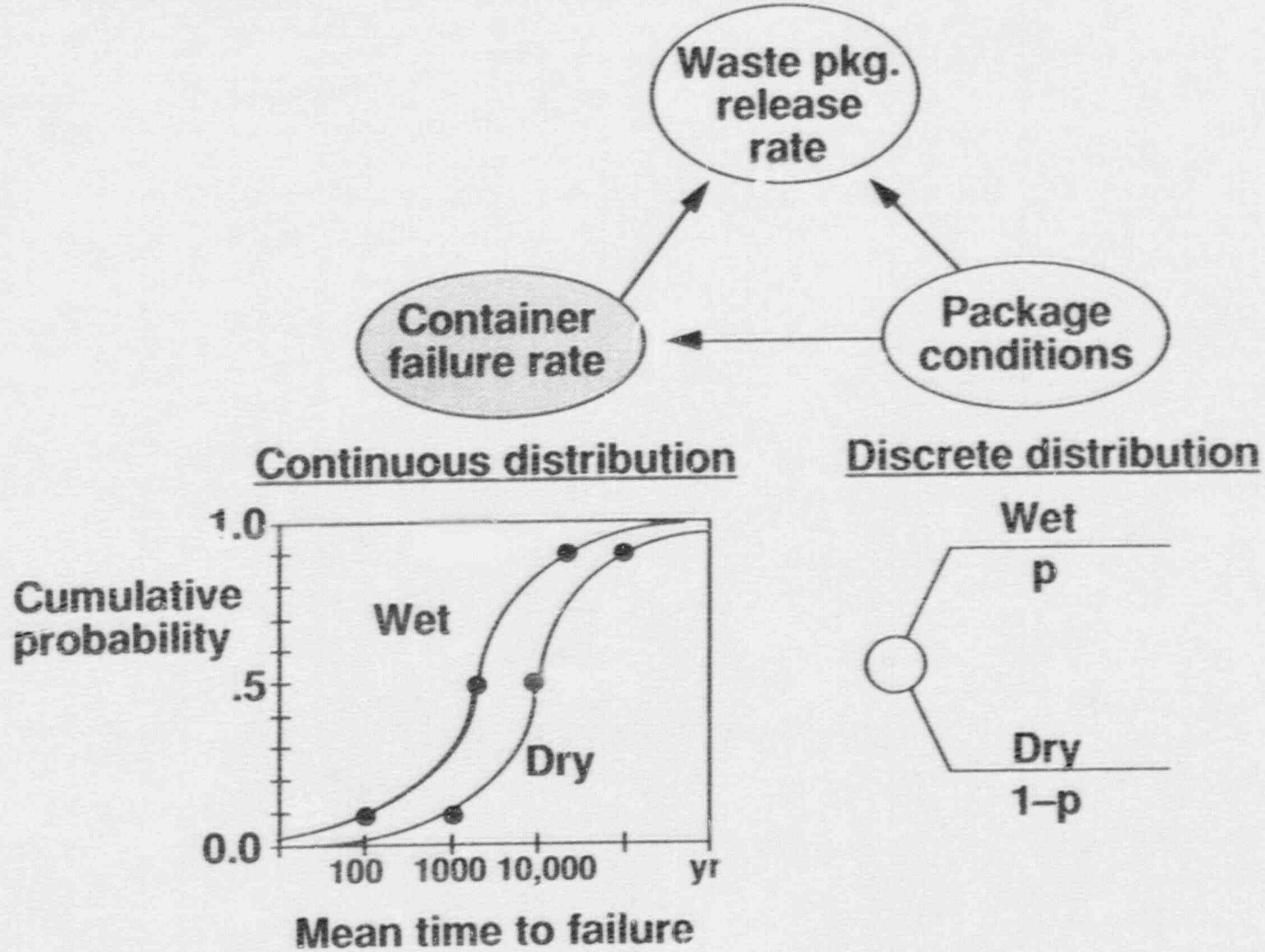
A panel of experts provided assessments for eight key uncertainties related to gas releases



Abbreviations:

AE	Accessible environment
C-14	Carbon-14
Ci	Curie
UZ	Unsaturated zone
WP	Waste package
y	Year

Most numerical assessments for the analysis are probability distributions on key uncertainties

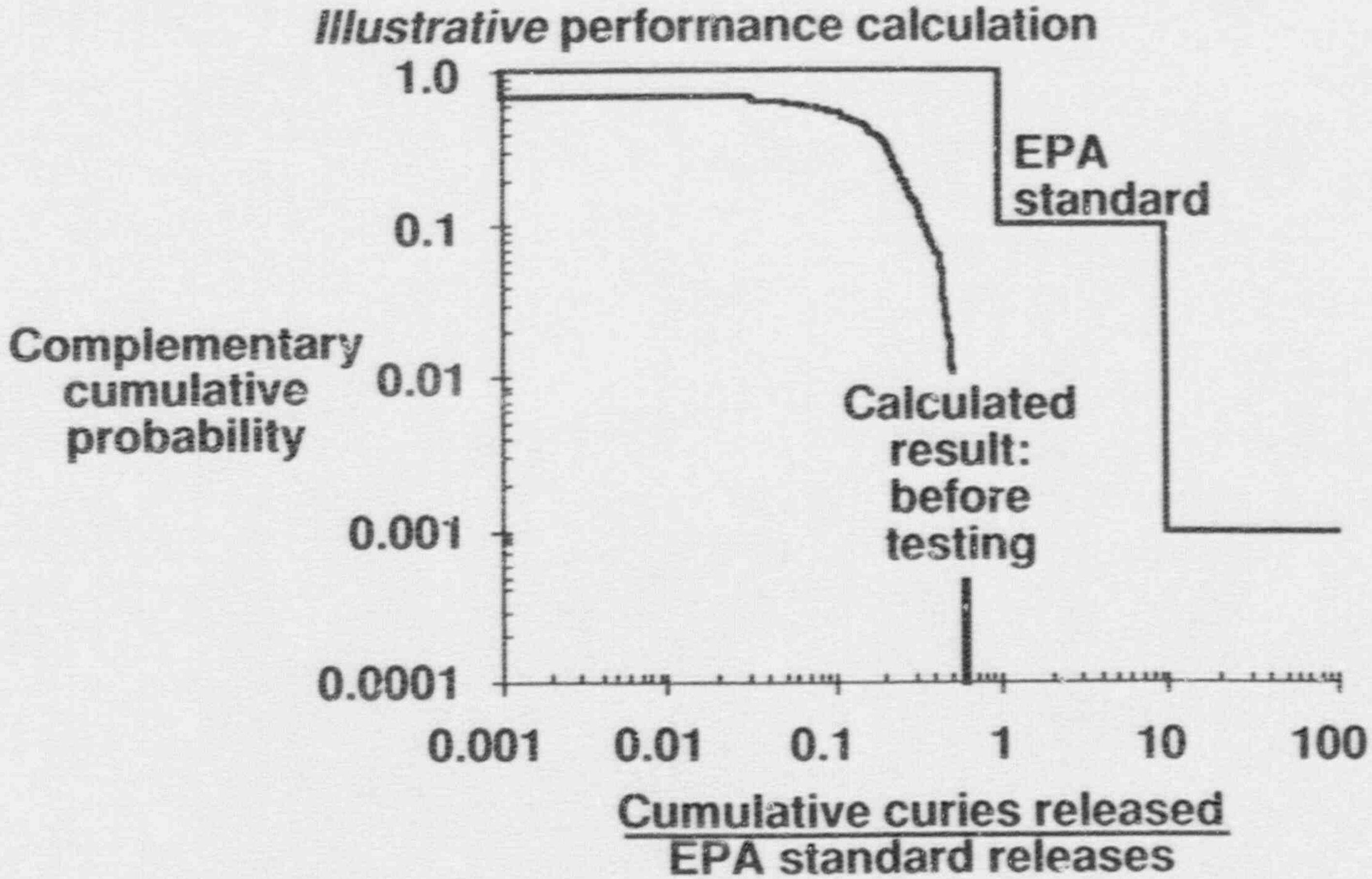


Initial assessments are 10, 50, and 90-percentile points to represent the entire probability distribution

Illustrative assessments

Typical base model assessments:	Percentile 10	50	90
C-14 inventory (ci/MTHM)	0.8	1.1	1.4
Rapid release fraction (percent)	1.	2.	3.5
Container failure rate (mean time to failure, in years)			
Wet or moist	100.	2,000.	20,000.
Dry	1,000.	10,000.	100,000.
Cladding failure half-life (years)			
Wet	5.	500.	1,000.
Dry	1,000.	10,000.	25,000.
Gas flow time in UZ (years)	10	50	300
C-14 retardation (multiplier)	1.	50.	500.
Flux (mm/year)	.1	.5	6.5
Sat. hydraulic conductivity (mm/yr)	.01	.5	10.

The model computes a performance curve for gaseous release of carbon-14 (before testing)



Data assessment and model development for test prioritization are time comsuming; this effort will be continued in Phase 2

Agenda

- Task overview
  - Test prioritization objectives
  - Task force participants
  - Phased approach and schedule

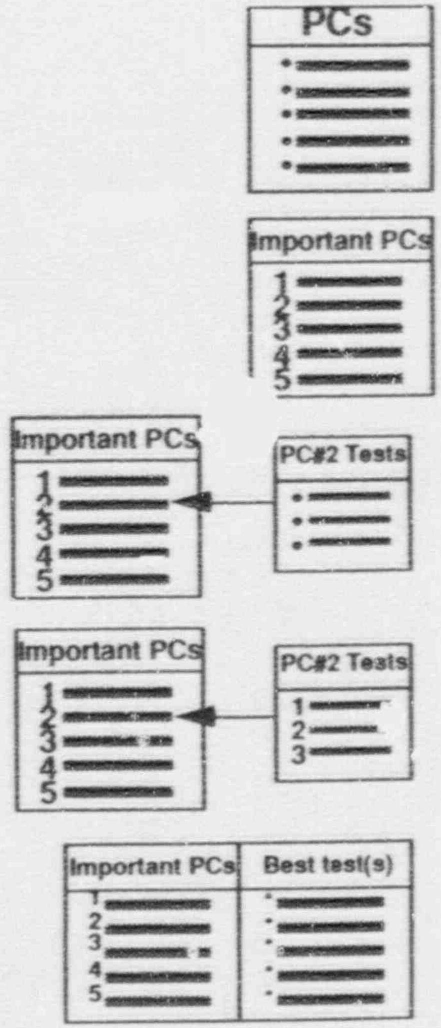
- Summary of the decision analysis approach
  - Focus on tests that affect early decisions
  - Decision criterion
  - Example analysis: gas-phase release

- Phase 1 application
  - Assessing the importance of potential concerns
  - Assessing the accuracy of testing
  - Prioritizing tests

- Summary and plan for Phase 2

A five-step approach has been developed for Phase 1 prioritization

1. Compile a list of potential concerns (PCs)
2. Assess and rank the importance of each PC to waste isolation
3. Compile a list of studies/tests addressing important PCs
4. Assess and rank the tests addressing important PCs
5. Evaluate testing priorities (Phase 1)



Step 1 Compile a list of potential concerns (PCs)

Sources

10 CFR Parts 60 and 960

- Potentially adverse conditions (PACs)
- Disqualifying conditions

Other concerns

Potential concern
(partial list)
• Gas flow radionuclide
• Reactive GW chemistry
• GW travel time < 1000y
• Usable water in controlled area
• ...
• ...

Definitions

Measures

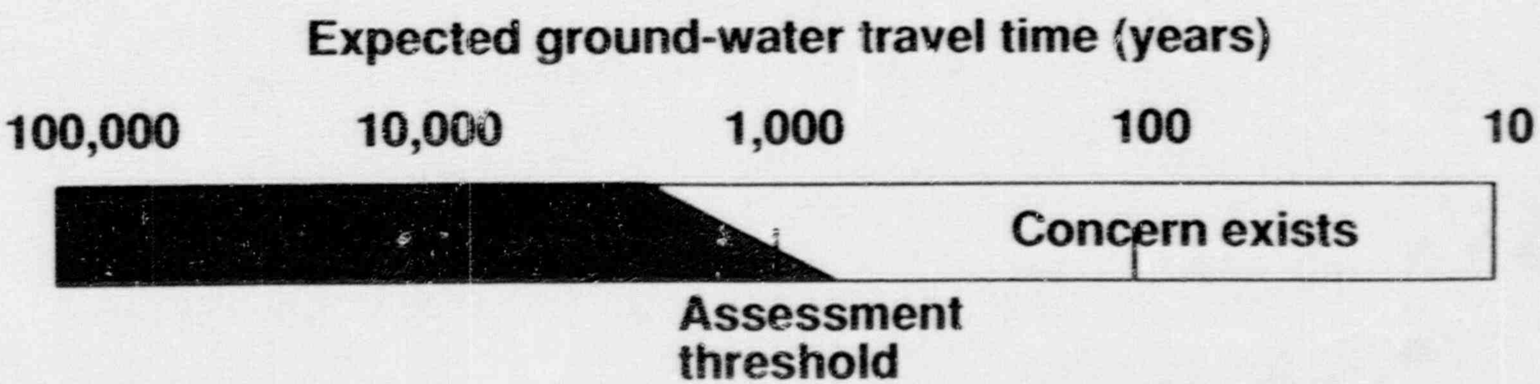
Assessment thresholds

Step 1 — Specify measures for each PC and threshold values for defining whether the concern exists

Potential concern: Ground-water travel time (GWTT)

Measure: Expected GWTT in years

Assessment threshold: 1000 years



Step 1

Example Assessment Thresholds

Potential concern*	Assessment threshold
Gas flow	Curies released by gas flow =2% of EPA standard
Complex geol.	Models underestimate releases by 10% of EPA standard
GWTT<1000	Expected GWTT=1000 years
Oxidizing GW	Eh=400 mV
Climate effects	Quaternary flux = 10 mm/year
Igneous activity	Existence during Quaternary (and future rate $=10^{-4}$ per 10k years on site)
Usable water	Ten times present SZ flux due to drilling

*This is a partial list of concerns

Step 2

Assess and rank the importance of each PC to waste isolation

Preliminary results

Potential concern*	Importance to waste isolation
Gas flow	.15
Complex geol.	.007
GWTT<1000	.000002
Oxidizing GW	.0000005
Climate effects	.00000002
Igneous activity	.000000003
Usable water	.000000002

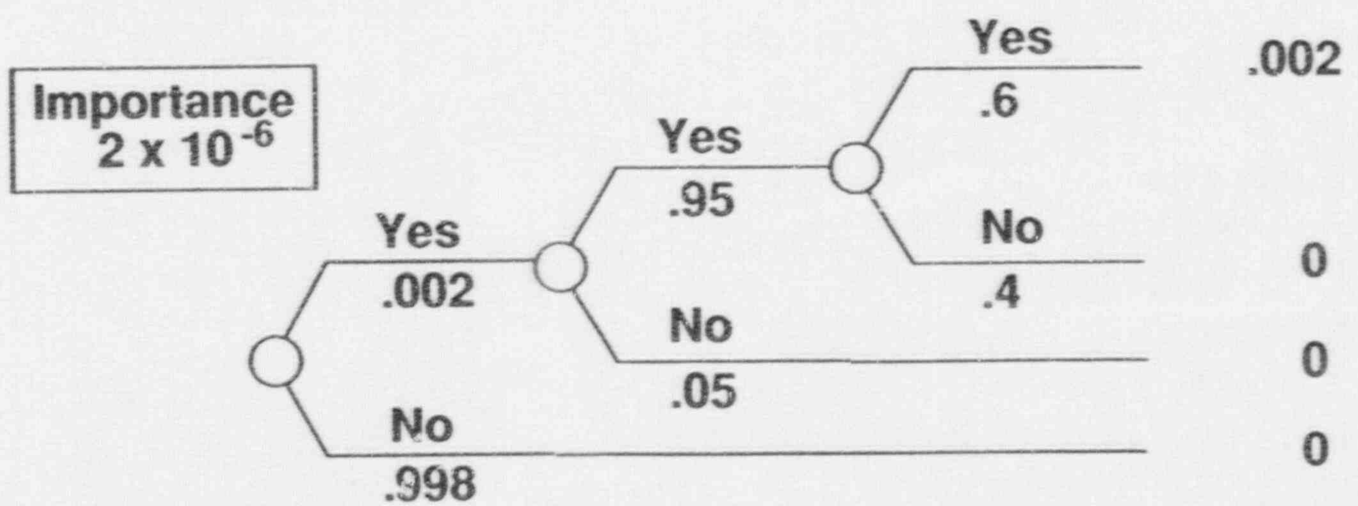
*This is a partial list of concerns

Step 2

A probability tree illustrates the assessments and importance calculation

Concern exceeds assessment threshold	Concern exists in next 10,000 y	Concern affects waste isolation	Incremental curies contributed

Potential concern:
expected ground-water travel time less than 1,000 years



Expected value (importance): $.002 \cdot .95 \cdot .6 \cdot .002 = .000002$

Step 2

Definitions of assessed probabilities

A = p(potential concern exists), i.e.,

= p(measure exceeds assessment threshold)

B1 = p(concern exists during next 10,000 yrs., given A)

B2 = p(concern affects waste isolation, given B1)

C = incremental curies released to accessible environment

= (multiplier on performance) • (baseline performance estimate)

– (baseline performance estimate)

where

Performance estimate = proportion of EPA standard releases

Baseline performance = proportion given that no concern exists

Multiplier = expected curies given B2÷baseline performance

Step 2

A sample of results shows substantial variation in assessments

Preliminary results

	← *Assessed*			→	← *Computed* →
Potential concern	Concern exceeds assessment threshold	Concern exists in next 10,000 y	Concern affects waste isolation	Incre-mental curies released	*Importance to waste isolation*
	A	B1	B2	C	A•B1•B2•C
Gas flow	.62	1.0	1.0	.24	.15
Complex geol.	.03	1.0	1.0	.25	.007
GWTT<1000	.002	.95	.6	.002	.000002
Oxidizing GW	.9	.99	.6	.000004	.0000005
Climate effects	.002	1.0	.3	.00002	.00000002
Igneous activity	.99	.00002	.2	.0007	.000000003
Usable water	.95	.05	.1	.0000004	.000000002

Step 2

Step 2 produced a prioritized list of potential concerns to be investigated

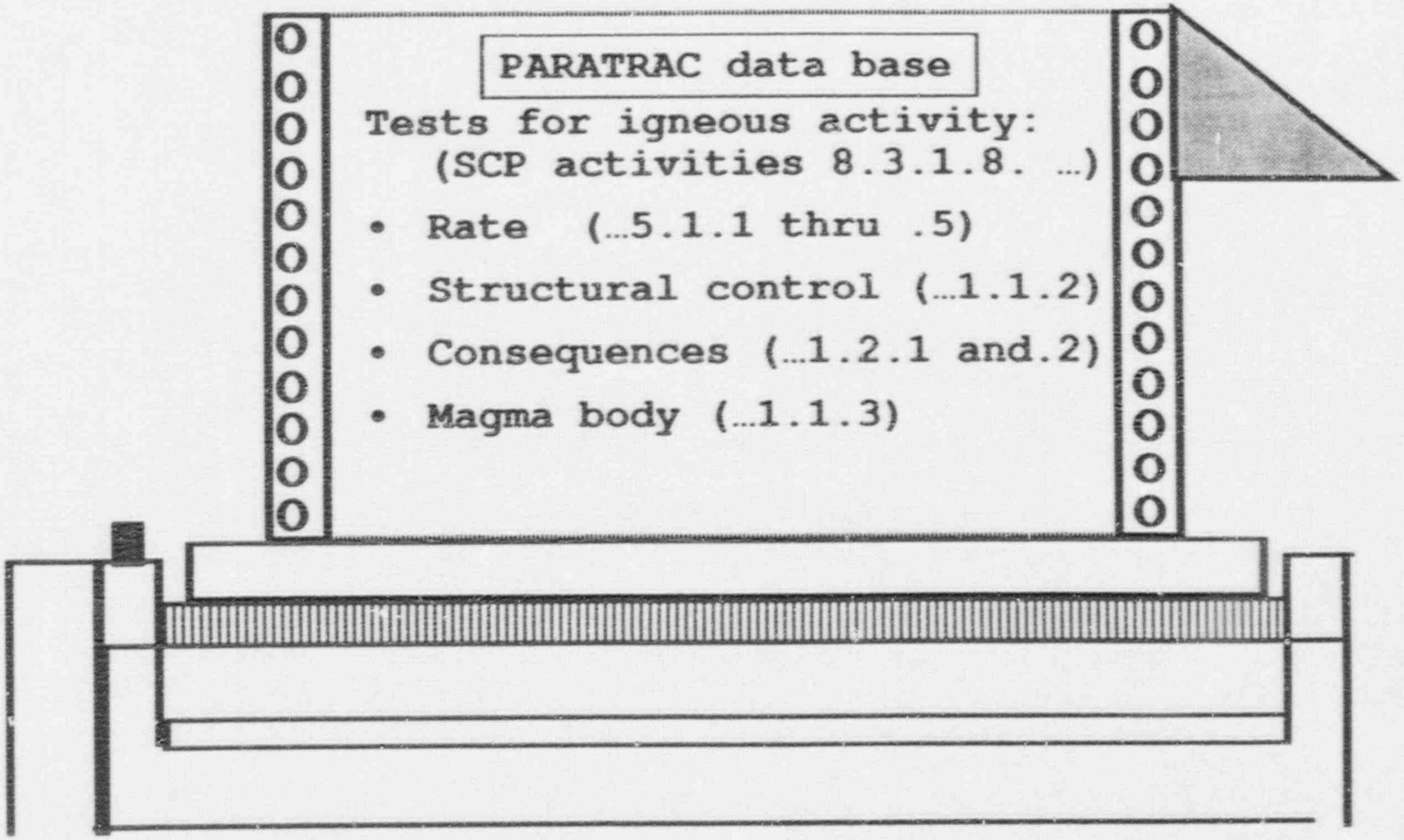
Preliminary results

Potential concern	Concern exceeds assessment threshold	Concern exists in next 10,000 y		Concern affects waste isolation	Incremental curies released	*Importance to waste isolation*
Gas flow	6e-1 ($6x10^{-1}$)	1e+0	A	1e+0	2e-1	.15
Complex geology–Gas	3e-1	1e+0	A	1e+0	7e-2	.02
Complex geology–Aqueous	3e-2	1e+0	A	1e+0	2e-1	.007
Direct human intrusion (HI)	3e-2	1e+0	B	2e-2	5e-2	.00003
Expected GWTT<1000y	2e-3	1e+0	B	6e-1	2e-3	.000001
Oxidizing GW in host rock	9e-1	1e+0	B	2e-1	3e-6	.0000005
Climate effect on Rn transport	2e-3	1e+0	C	3e-1	2e-5	.00000002
HI effects on geohydrology	2e-3	1e+0	C	6e-1	2e-5	.00000001
Natural resources	2e-3	6e-3	C	7e-1	2e-3	.00000001
Perched water	3e-2	6e-1	C	1e-1	[illegible]e-6	.000000008
UO2 solubility	5e-3	1e+0	C	4e-1	2e-6	.000000004
Past igneous activity	1e+0	2e-5	C	2e-1	7e-4	.000000003
Reactive GW chemistry	4e-4	1e+0	C	2e-1	3e-5	.000000002
Usable water in CA: SZ	1e+0	5e-2	C	9e-2	4e-7	.000000002
Water table rise: 200m	1e-4	1e-2	D	8e-1	5e-4	.0000000005

-
- Note: "6e-1" means 6×10^{-1}
-

Step 3

Compile a list of studies/tests addressing important PCs



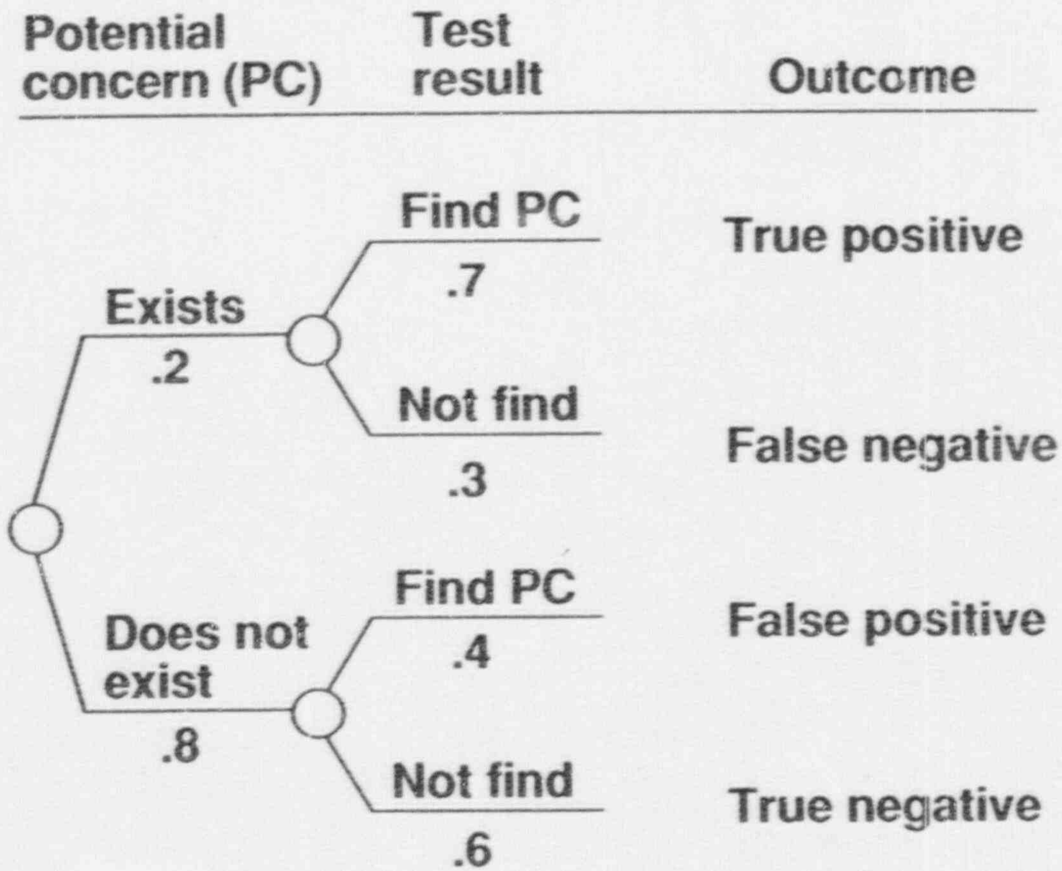
Step 4

Assess and rank tests that address important potential concerns

Potential concern	Possible tests	Test package	Rank
Igneous activity	Rate	1	*1?*
	Structural control		
	Consequences		
	Magma body	2	*2?*

Step 4

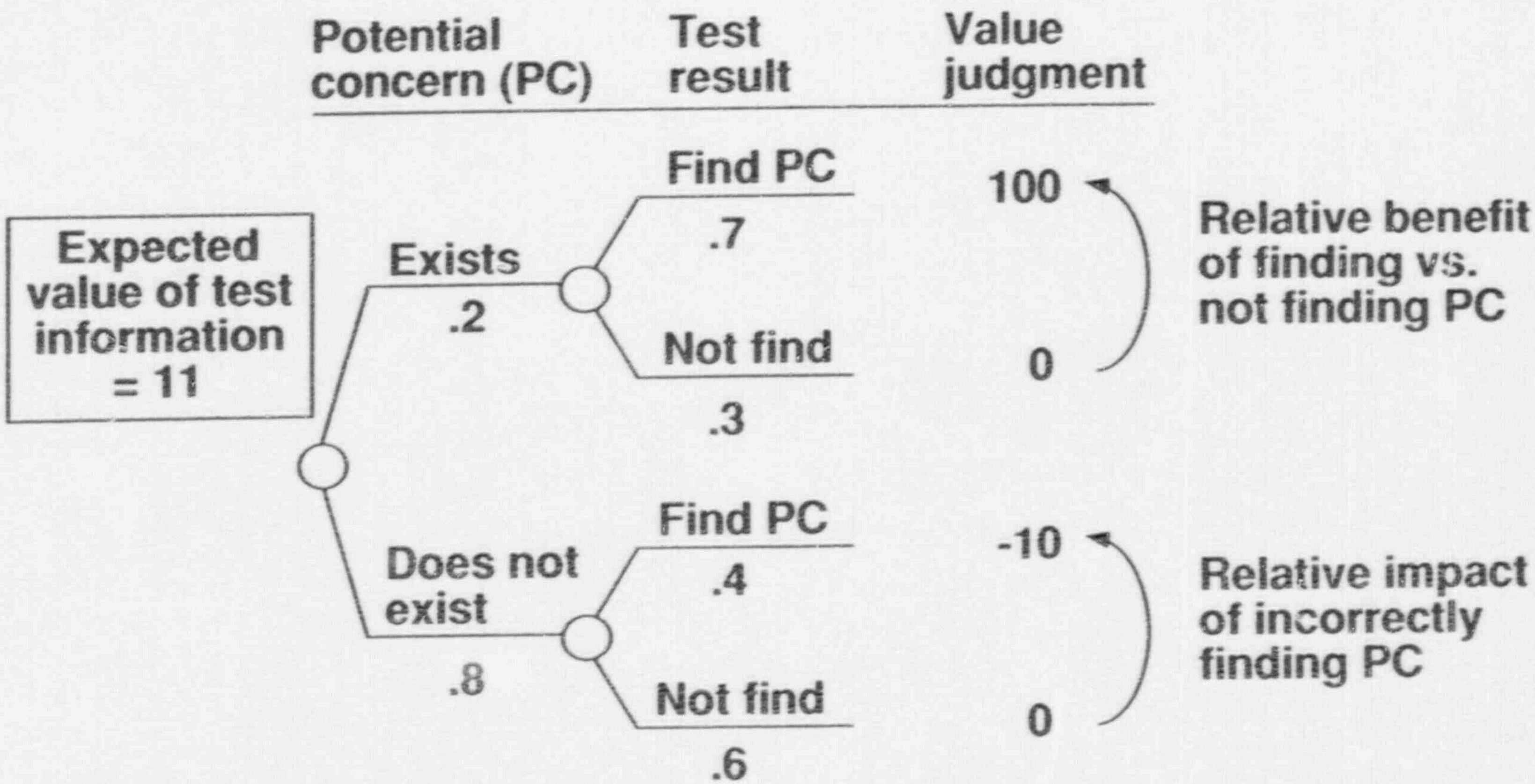
First, tests are evaluated based on their accuracy in detecting potential concerns



Accuracy: $.2 \times .7 + .8 \times .6 = .62$

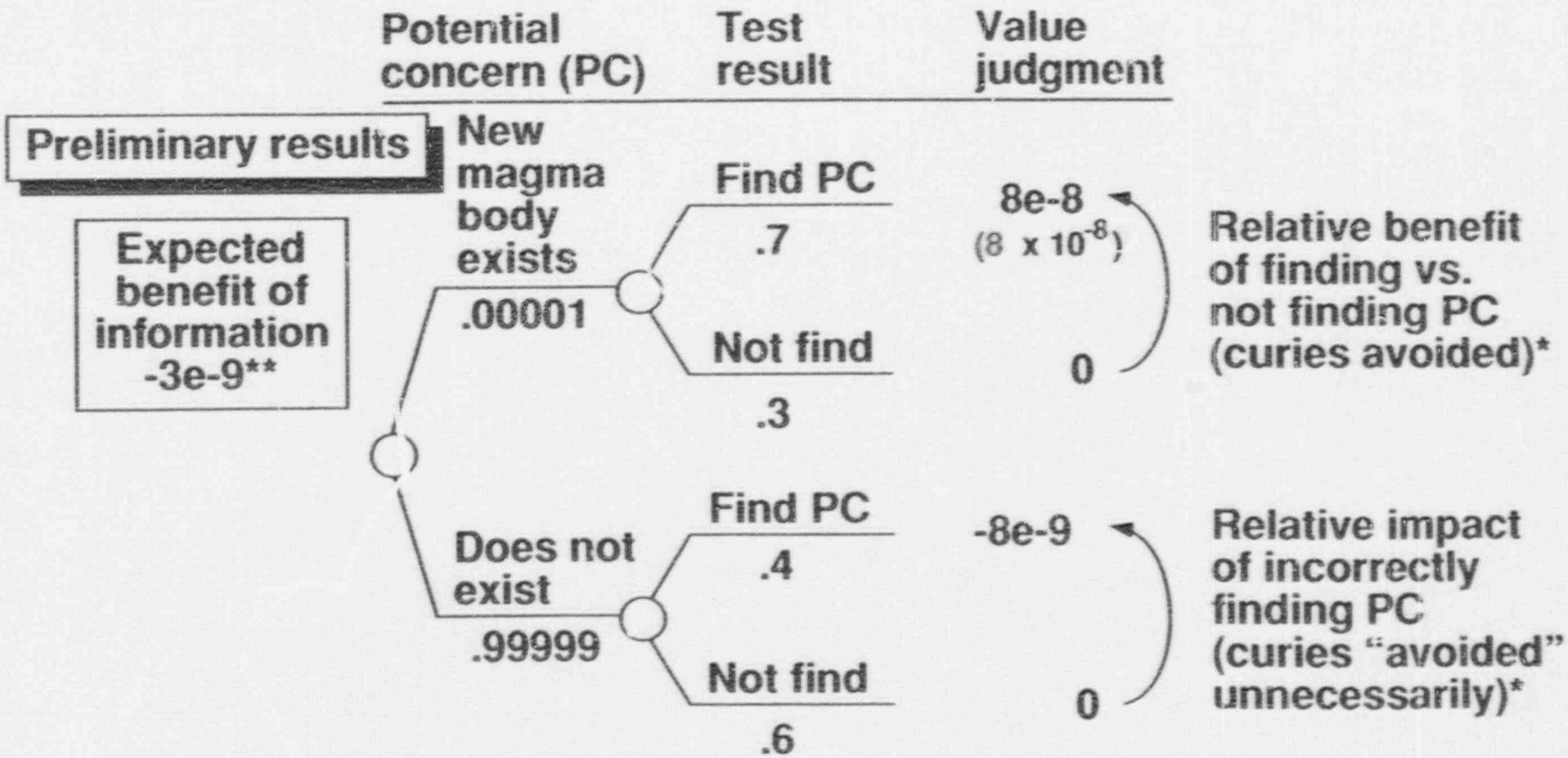
Step 4

Second, the consequences of correct and incorrect conclusions are incorporated



Expected value of test information = .2 • .7 • 100 + .8 • .4 • (– 10)
= 14 – 3
= 11

Step 4 Consider a teleseismic test for a possible magma body under the repository



Expected benefit of test information = .6e-12 – 3e-9 = –3e-9**

*Assuming action is taken based on test results

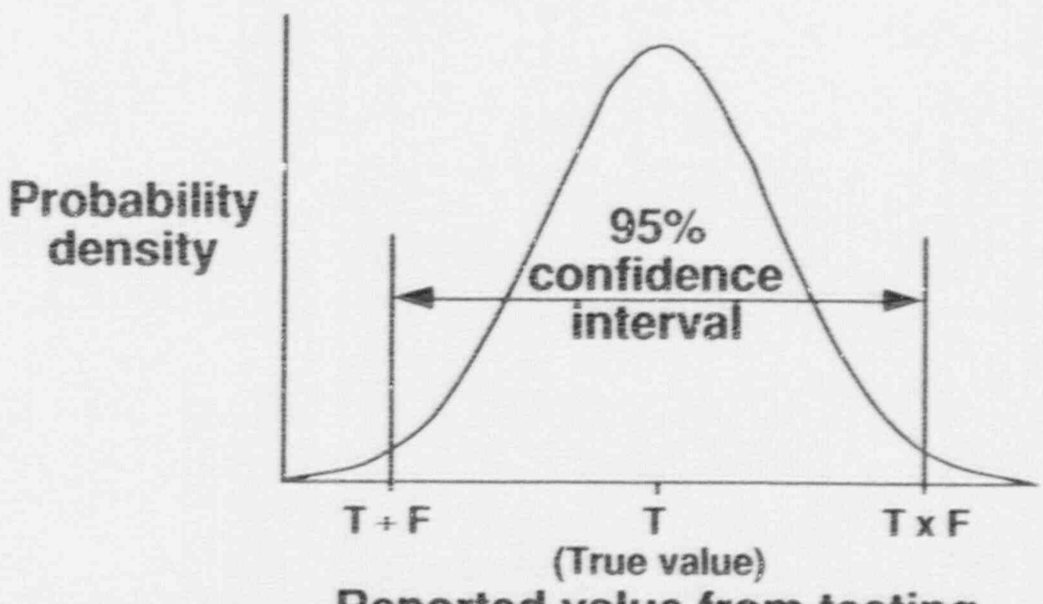
**Negative values indicate action shouldn't be taken based on test results. If no action is taken based on test results, the test has no value of information.

Step 4

Testing for continuous parameters may require a different quantification of test accuracy

Possible assessment question:

What is the factor, F, such that if the *true* value of the variable is T, there is 95% chance that the *reported* value will lie in the interval T÷F to T x F?



Example:

Freq. of igneous events

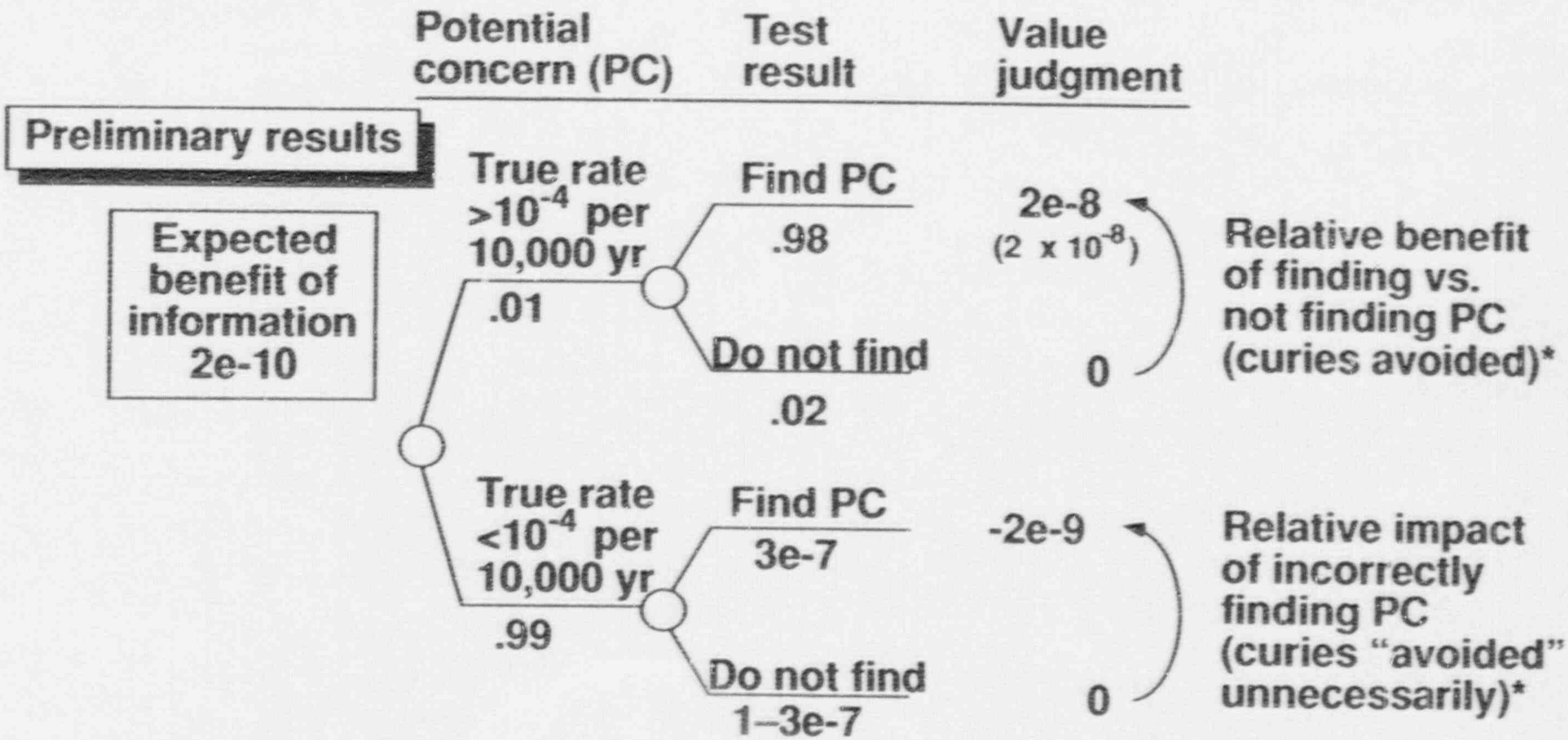
True value:

T = one event / 200,000 y

Testing accuracy:
F = "factor-of-2"

Meaning:
There is a 95% chance that the reported value will fall between 100,000 and 400,000 years.

Step 4 — Another test for igneous activity is to investigate the rate of formation of volcanic centers on site



Expected benefit of test information = 2e-10 − 6e-16 = 2e-10

*Assuming action is taken based on test results

Step 4

Accuracy and consequence assessments facilitate the ranking of tests for each PC

Preliminary results

← *Assessed* → *Computed*

Potential concern (PC)	P(PC exists)	Possible tests	P(find | PC exists)	Benefit of find | PC exists	P(find | PC not exist)	Impact of find | PC not exist	Expected value of test
	A		F	H	G	I	AFH+(1-A)GI
Igneous activity	.01	Rate test	.98	2e-8	3e-7	–2e-9	+2e-10
	1e-5	Magma body test	.7	8e-8	.4	–8e-9	–3e-9

This analysis identifies the "best" test package for each PC

Step 5 Step five ranks potential concerns taking into account the accuracy of the best test packages

Illustrative data

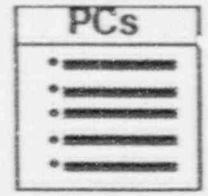
Assessed ——————→ *Computed*

Potential concern (PC)	P(PC exists)	Possible tests	P(find | PC exists)	Benefit of find | PC exists	P(find | PC not exist)	Impact of find | PC not exist	Expected value of test
	A		F	H	G	I	AFH+(1-A)GI
Gas flow	.62		.7	.24	.4	–.024	.10
Complex geol.	.03		.8	.25	.4	–.025	.004
Oxidizing GW	.9		.8	5e-7	.3	–5e-8	3e-7
Usable water	.95		1.0	2e-9	.01	–2e-10	2e-9
Igneous activ.	.01*	Rate	.98	2e-8	3e-7	–2e-9	2e-10
Climate effect	.002		.6	8e-6	.5	–8e-7	–4e-7
GWTT<1000y	.002		.8	9e-4	.3	–9e-5	–3e-5

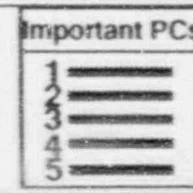
*Note: definition of assessment threshold differs from earlier slides.

Step 5 — Step 5's ranking on the benefits of testing differs from the importance ranking in Step 2

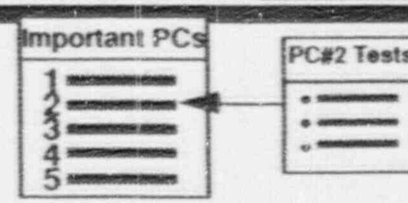
1. Compile a list of potential concerns (PCs)



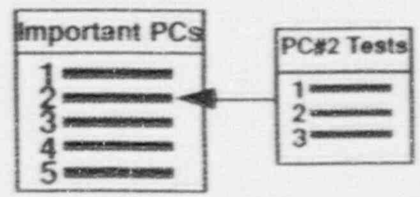
2. Assess and rank the importance of each PC to waste isolation



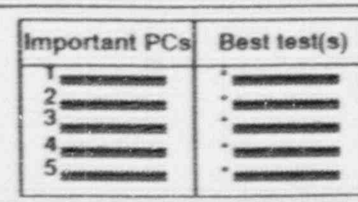
3. Compile a list of studies/tests addressing important PCs



4. Assess and rank the tests addressing important PCs



5. Evaluate testing priorities (Phase 1)



Step 5

The priority for investigating concerns changes when test accuracy is considered

Illustrative results

Important potential concerns from Step 2*	Test priorities from Step 5*	Comments
Gas flow	Gas flow	High exp. value of information
Complex geol.	Complex geol.	Moderate exp. value of info.
GWTT<1000 y	Oxidizing GW	Low exp. value of info.
Oxidizing GW	Usable water	Low exp. value of info.
Climate effects	Igneous activity	Low exp. value of info.
Igneous activity	Climate effects	High prob. of false positive
Usable water	GWTT<1000 y	High prob. of false positive

*This is a partial list of concerns

Step 5 Rankings based on expected value of information may be revised to account for other factors

Possible *other reasons* for testing

1 Facilitating other tests (e.g., drilling boreholes)
2 Initiating long-duration performance-confirmation tests
3 Gathering information for design or construction
4 Providing additional information required for licensing
5 Building scientific consensus and public confidence
6 ...

Priorities may need to be revised based on these considerations

Step 5

These other factors can be incorporated in the prioritization

Illustrative data

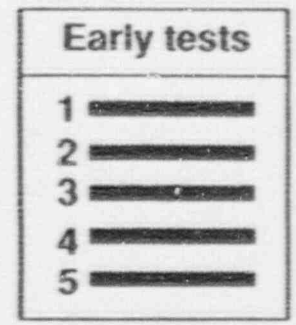
Potential concern	Expected value of best test(s)	Other importance of investigation	Cost of investigation	Total benefit
	Computed	← *Assessed*	*Assessed* →	*Computed*
	J	K	L	M=J+K+L
Gas flow	.10			
Complex geol.	.004			
Oxidizing GW	.0000003			
Usable water	.000000002	??	$??	
Igneous activ.	.0000000002			
Climate effect	–.0000004			
GWTT<1000y	–.00003			

Agenda

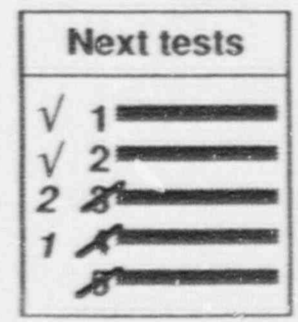
- Task overview
  - Test prioritization objectives
  - Task force participants
  - Phased approach and schedule
- Summary of the decision analysis approach
  - Focus on tests that affect early decisions
  - Decision criterion
  - Example analysis: gas-phase release
- Phase 1 application
  - Assessing the importance of potential concerns
  - Assessing the accuracy of testing
  - Prioritizing tests
- Summary and plan for Phase 2

Summary

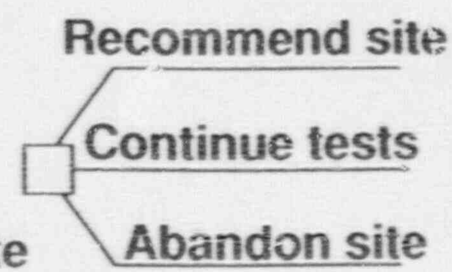
- The test prioritization analysis produces a ranked list of tests that can provide early detection of potential concerns



- The approach provides management with an ongoing tool to re-prioritize testing at any point during site characterization

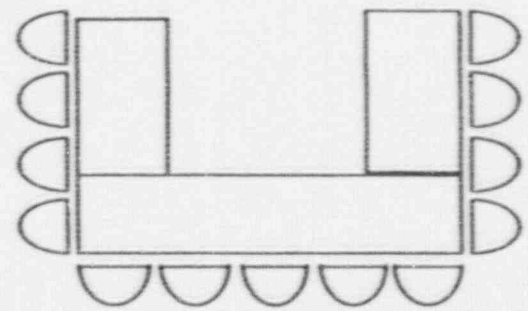


- Coupled with a site-suitability decision analysis, these methods provide a *defensible* means for
  - Determining the value of tests
  - Deciding whether or not to continue testing
  - Deciding whether or not to recommend the site



Status of Phase 2 Application

Work in 1990



- Methodology development
- Model development (hydrology; gas)
- Influence diagramming
- 7 workshops with expert panels

Planned for 1991

- 15–25% of model remaining to be completed
- 10–25 expert panel assessments on
  - Parameter uncertainties
  - Test accuracy
- Analysis
  - Sensitivity analysis
  - Consideration of model uncertainties
  - Test priorities
- Reporting

A FOLLOWUP WORKSHOP TO THIS ONE IS PLANNED FOR SPRING '91. WORKING GROUPS ARE ASKED TO FORMULATE KEY QUESTIONS THAT NEED TO BE ADDRESSED AT THIS SPRING W-SHOP. EACH WORKING GROUP IS TO ADDRESS EACH OF THE FOLLOWING:

1. HOW SHOULD THE TOPICS FOR FUTURE WORKSHOPS BE SELECTED? → Uncertainties?

   Speciation — Hydro Performance — Volcanism — Ground Water Travel Time

2. HOW COULD SUCH WORKSHOPS BE STRUCTURED TO:

   a. FACILITATE ISSUE RESOLUTION?

   b. PROMOTE COMMUNICATION?

3. IDENTIFY OTHER KEY CONCERNS.

REFERENCES: (ATTACHED)

GOALS
PROCESS: RISK/DECISION METHODOLOGY
STATEMENT OF EPRI PROJECT OBJECTIVES.

PROCESS: RISK/DECISION METHODOLOGY

1. MEETING(S) ON:
   - METHOD OF SPECIFYING RANGE OF MODELS/PARAMETERS/ASSUMPTIONS, AND PROBABILITIES.
   - METHOD OF ENSURING PROPER INTERACTION AMONG TECHNOLOGIES
   - RULES OF APPLICATION:
     - USE OF DATA
     - CONSIDERATION OF ALTERNATIVES
   - USE OF RESULTS
2. MEETING(S) ON SPECIFIC TECHNOLOGIES.
3. MEETING(S) ON INTERACTIONS.
4. MEETING(S) ON RESULTS/SENSITIVITIES/CONCLUSIONS.