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

PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: CALICO HILLS RISK/BENEFIT ANALYSIS - OVERVIEW OF THE GEOTECHNICAL INPUT

PRESENTER: ERNEST L. HARDIN

PRESENTER'S TITLE AND ORGANIZATION: STAFF SCIENTIST, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

PRESENTER'S TELEPHONE NUMBER: (702) 794-7616

JULY 24-25, 1990

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: CALICO HILLS RISK/BENEFIT ANALYSIS - OVERVIEW OF THE GEOTECHNICAL INPUT

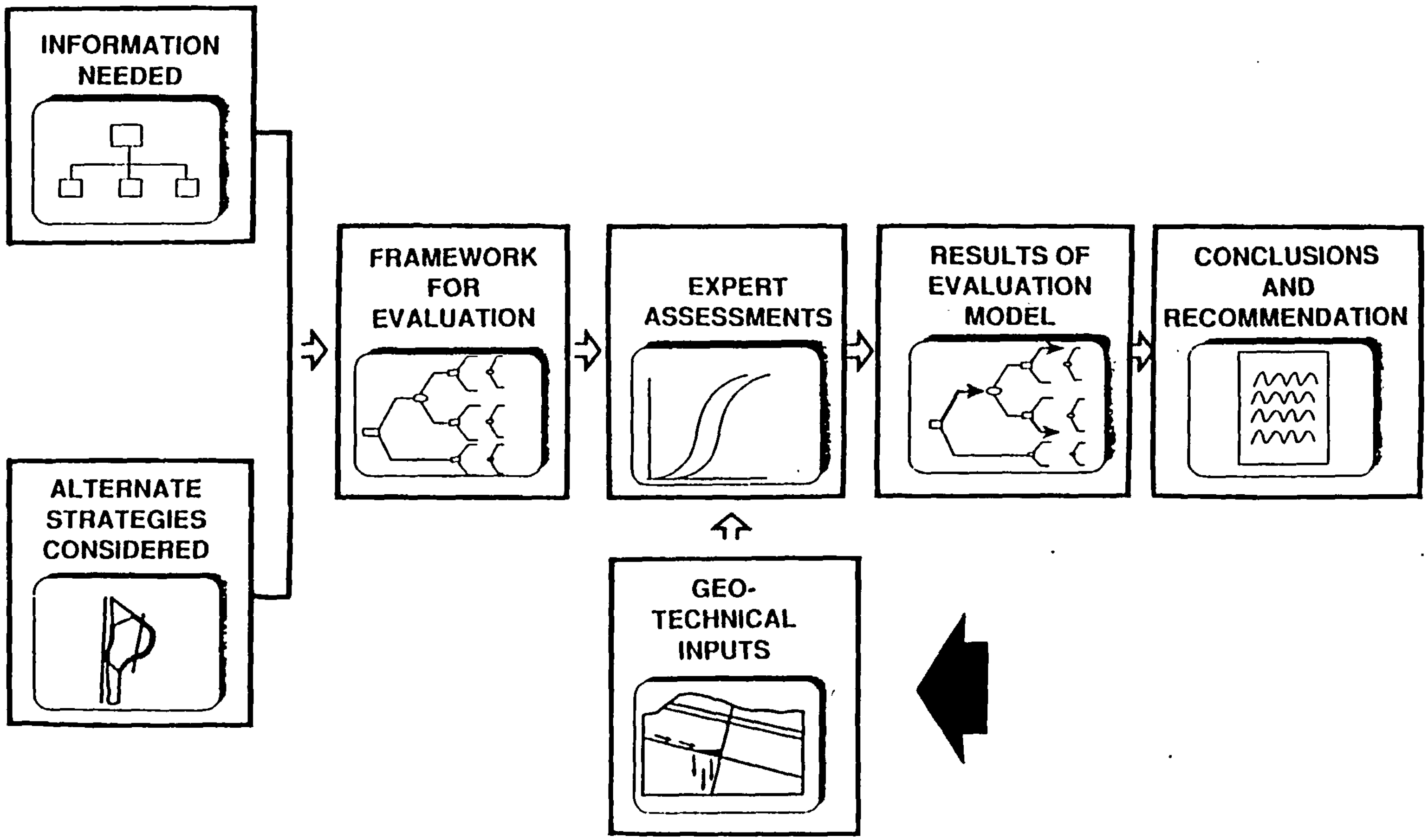
PRESENTER: ERNEST L. HARDIN

PRESENTER'S TITLE AND ORGANIZATION: STAFF SCIENTIST,
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

PRESENTER'S TELEPHONE NUMBER: (702) 794-7616

JULY 24-25, 1990

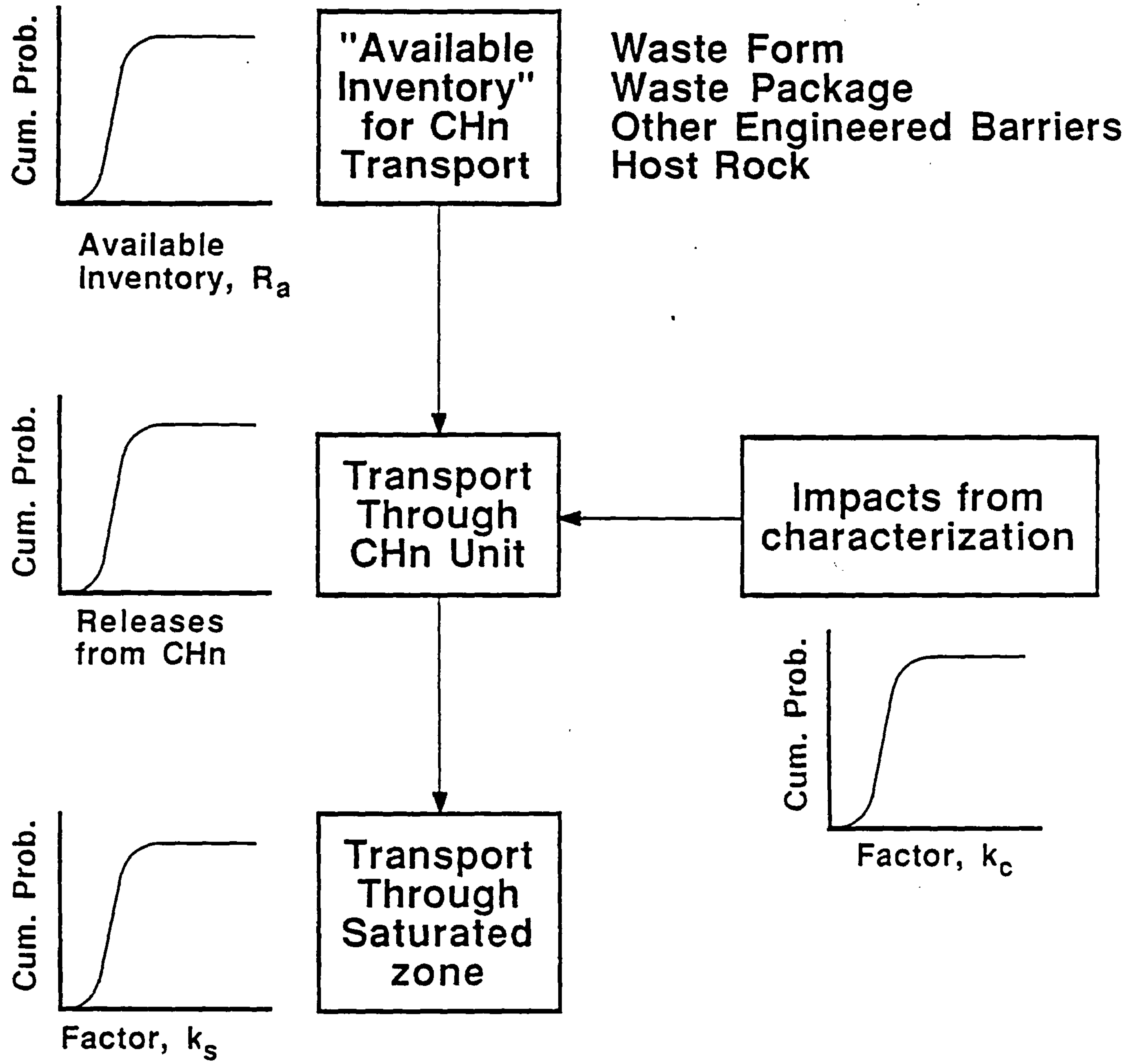
STRUCTURE OF THE CALICO HILLS RISK/BENEFIT PRESENTATION



OVERVIEW OF TECHNICAL INPUTS

- CONCEPTUAL MODELS
  - LINEAR MODEL FOR TOTAL SYSTEM PERFORMANCE
  - PERFORMANCE MEASURE
  - FLOW REGIMES
- TECHNICAL INPUTS
  - PROBABILITIES OF FLOW REGIMES
  - TEST LIKELIHOOD FUNCTIONS
  - "AVAILABLE INVENTORY," SOURCE-TO-CHn
  - TRANSPORT THROUGH THE CHn UNIT
  - SATURATED ZONE TRANSPORT
  - WASTE ISOLATION IMPACTS FROM TESTING
- SUMMARY

CONCEPTUAL MODELS
LINEAR MODEL FOR TOTAL SYSTEM



CONCEPTUAL MODELS

PERFORMANCE MEASURE

- **TOTAL SYSTEM PERFORMANCE (40 CFR 191)**

$$"R" = \sum \frac{R_i}{A_i}$$

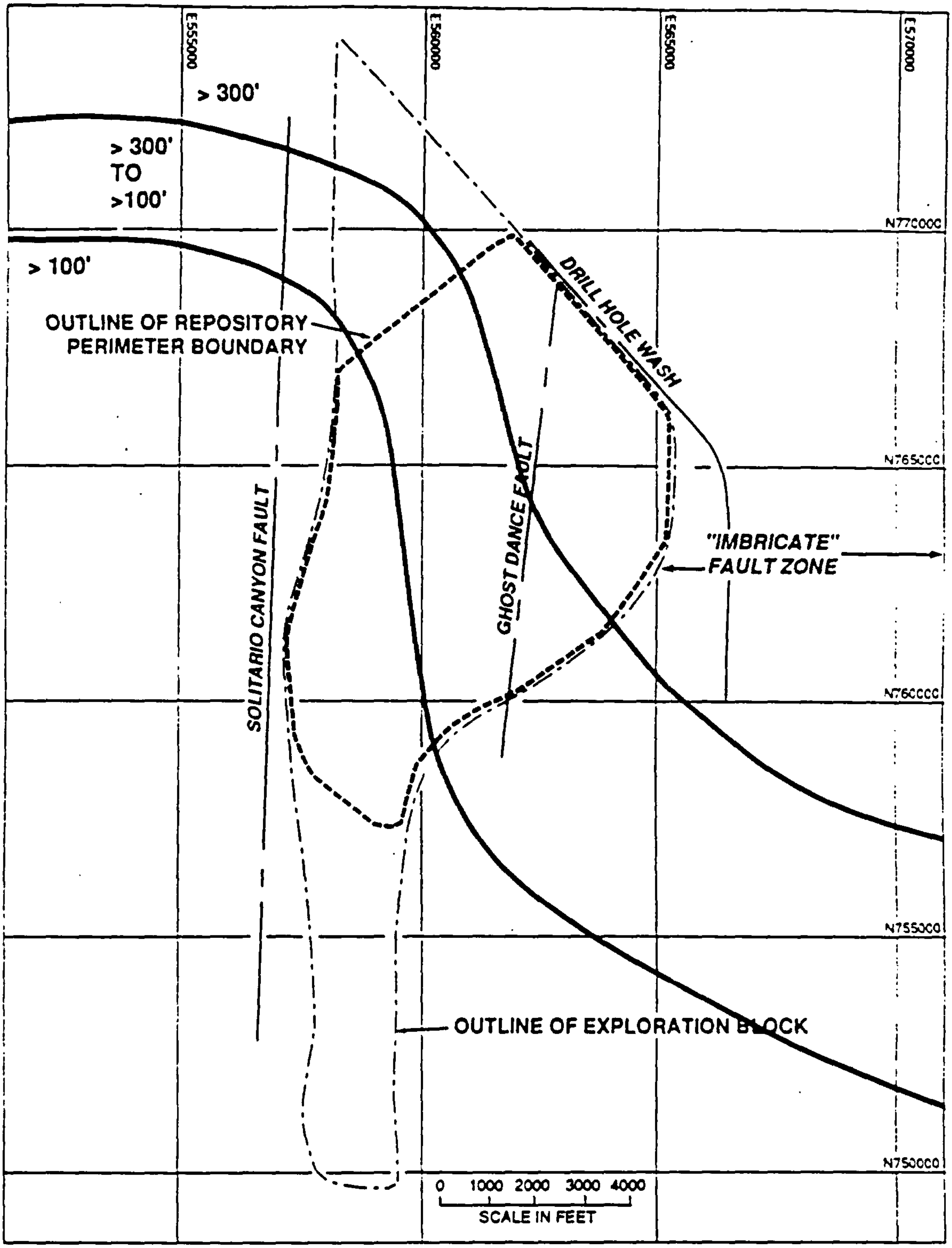
R_i — RELEASE, RADIONUCLIDE i

A_i — TABULATED RELEASE LEVEL

"R" IS ASSESSED DIRECTLY BY CHRBA

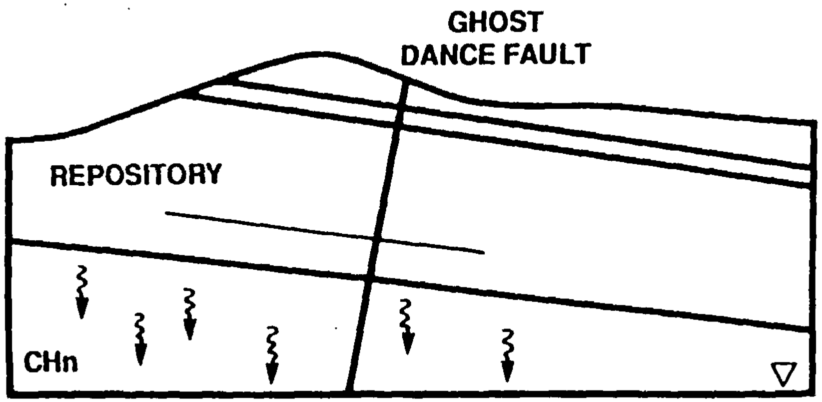
- **ASSUMED "MIX" OF RADIONUCLIDES AVAILABLE FOR TRANSPORT:**
  - VOLUME FRACTION
  - ENRICHED IN MOBILE SPECIES, e.g., Tc-99

SCHEMATIC MAP OF PROPOSED REPOSITORY AREA SHOWING STRUCTURAL FEATURES AND THICKNESS OF ZEOLITIZED CALICO HILLS UNIT

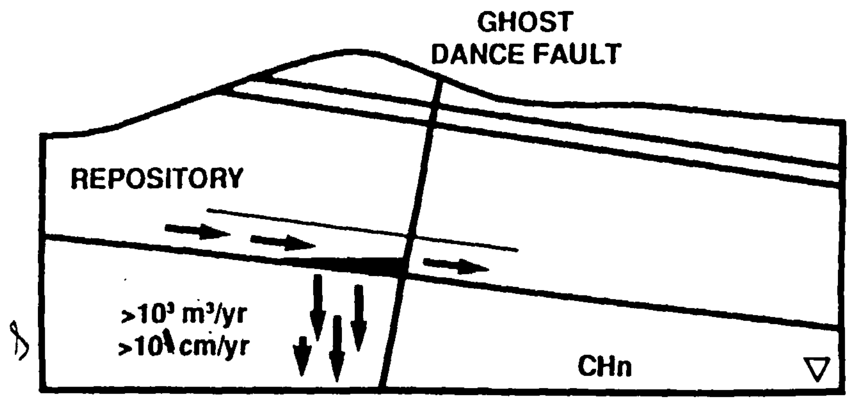


CONCEPTUAL MODELS
FLOW REGIMES

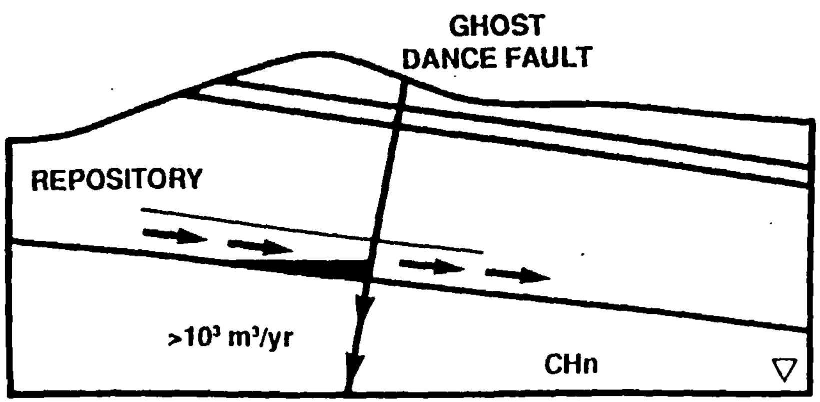
SLOW MATRIX (SM)



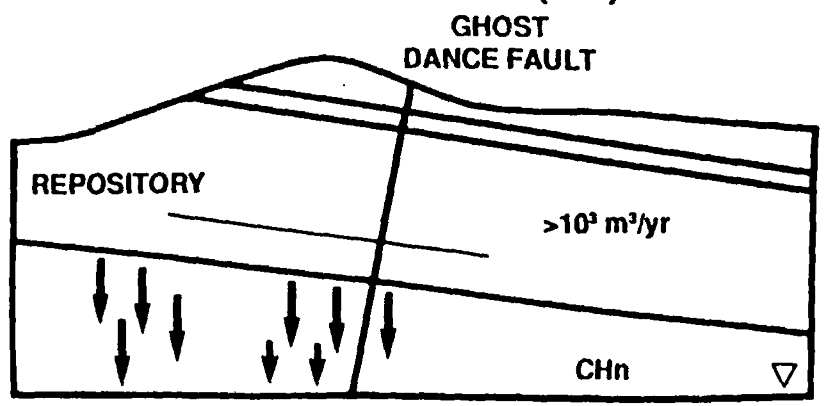
FAST MATRIX (FM)



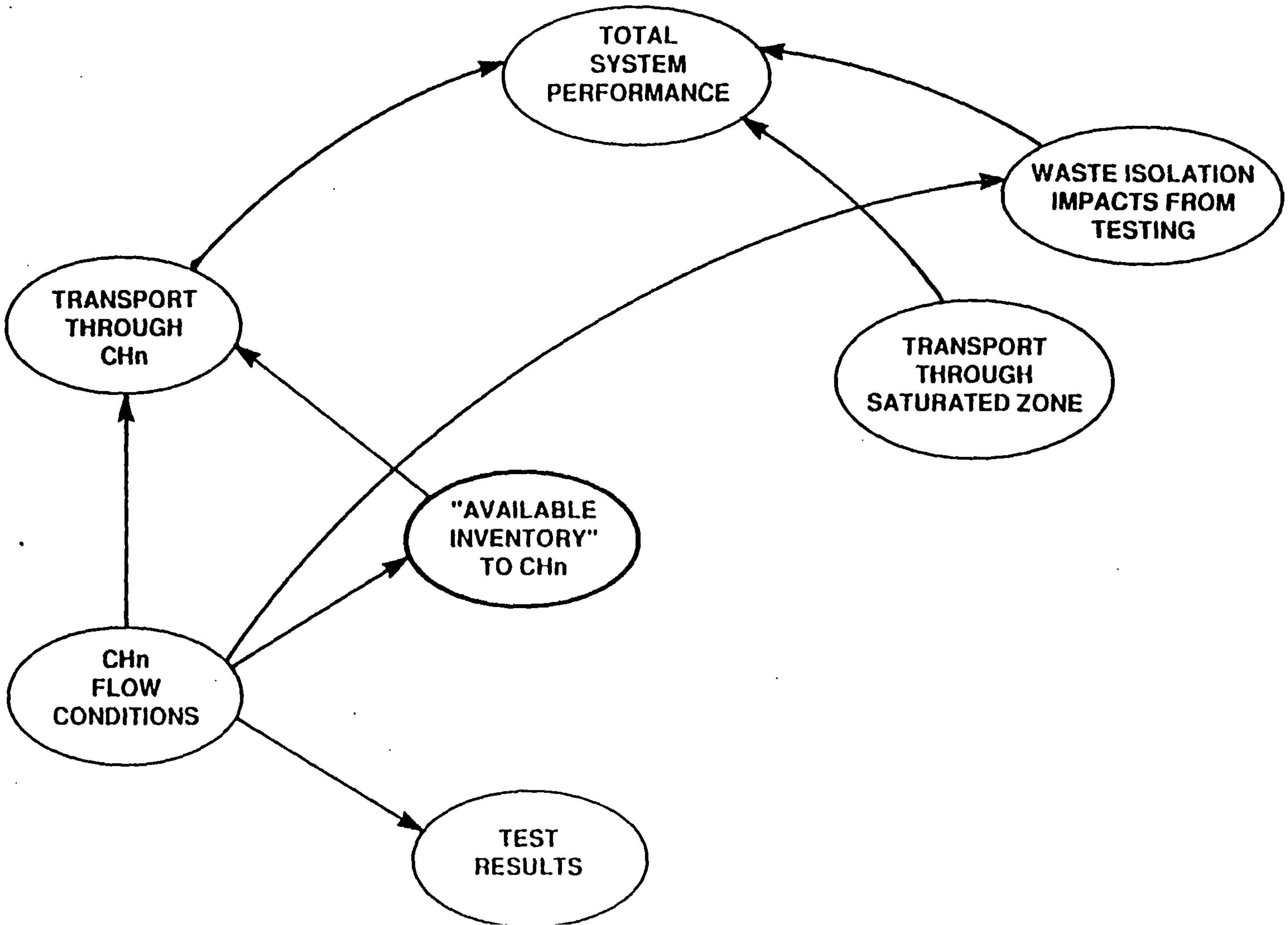
CONCENTRATED FRACTURE (CF)



DISTRIBUTED FRACTURE (DF)



IDENTIFY KEY UNCERTAINTIES AND PROBABILISTIC RELATIONSHIPS



TECHNICAL INPUTS

PROBABILITIES OF FLOW REGIMES

ASSESS PROBABILITY THAT EACH FLOW REGIME WILL PREVAIL OVER 10,000 YR

MAJOR INFLUENCE	DETAILS CONSIDERED
TOTAL FLUX	RETURN TO PLUVIAL CONDITIONS
CAPILLARY/PERMEABILITY BARRIERS	TSw – CHn CONTACT CHn FACIES TRANSITIONS
FLUX CONCENTRATING MECHANISM	DISTRIBUTION OF FLUX PRODUCED BY OVERLYING UNITS AND PROCESSES
MATRIX HYDRAULIC PROPERTIES	CHn FACIES DISTRIBUTION
FRACTURE HYDRAULIC PROPERTIES	MINERAL COATINGS ON FRACTURE WALLS

PROBABILITIES FOR FLOW CONDITIONS:

SM	FM	CF	DF
.69	.06	.11	.14

TECHNICAL INPUTS

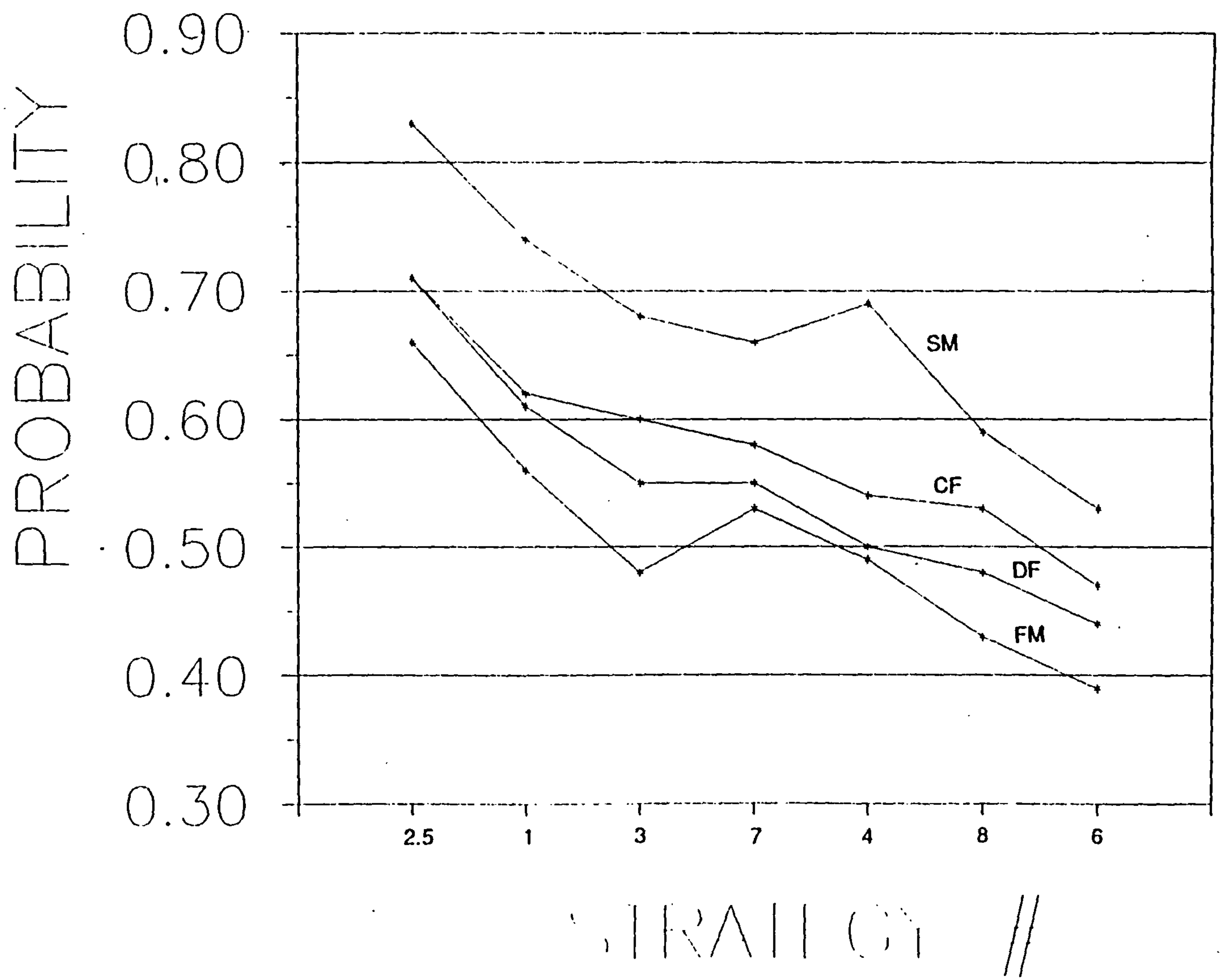
TEST LIKELIHOOD FUNCTIONS

PANELISTS ASSESSED HOW LIKELY THEY WOULD BE TO CONCLUDE EACH FLOW REGIME:

- GIVEN ONE FLOW REGIME IS THE CORRECT RESULT
- GIVEN RESULTS FROM EACH STRATEGY

MAJOR INFLUENCE	DETAILS CONSIDERED
TOTAL FLUX	UNCERTAINTY OF FUTURE CHANGES IN FLUX AFFECTS ALL LIKELIHOODS
FLUX CONCENTRATING MECHANISM	TEST STRATEGY LOCATION
HYDRAULIC CONDUCTIVITY	K_{sat} FOR ZEOLITIC CHn TOO LOW FOR FM FLOW
FRACTURE HYDRAULIC PROPERTIES	EXTENT OF UNDERGROUND EXPLORATION OF TARGETED FAULTS/FEATURES
	EXTENT OF EXPOSURE OF FRACTURE MINERALIZATION

PROBABILITIES OF CORRECTLY IDENTIFYING FLOW REGIMES



TECHNICAL INPUTS

SUMMARY OF TEST LIKELIHOOD FUNCTION

- UNDERGROUND EXCAVATION STRATEGIES WERE MORE LIKELY TO PRODUCE CORRECT RESULTS
- A PROW PASS (OUTCROP) TEST FACILITY WOULD HAVE LIMITED REPRESENTATIVENESS
- A SINGLE, SMALL U/G FACILITY IN THE SOUTH OR SOUTHEAST HAS LOW LIKELIHOOD OF PRODUCING CORRECT RESULTS, WHETHER IT IS INSIDE OR OUTSIDE THE BLOCK
- AN EXTENSIVE FACILITY SOUTHEAST OF THE BLOCK IS COMPARABLE TO A SMALL FACILITY INSIDE THE NORTHEAST PART OF THE BLOCK
- STRATEGIES 2 AND 5 HAVE SIGNIFICANTLY HIGHER LIKELIHOOD OF PRODUCING CORRECT RESULTS

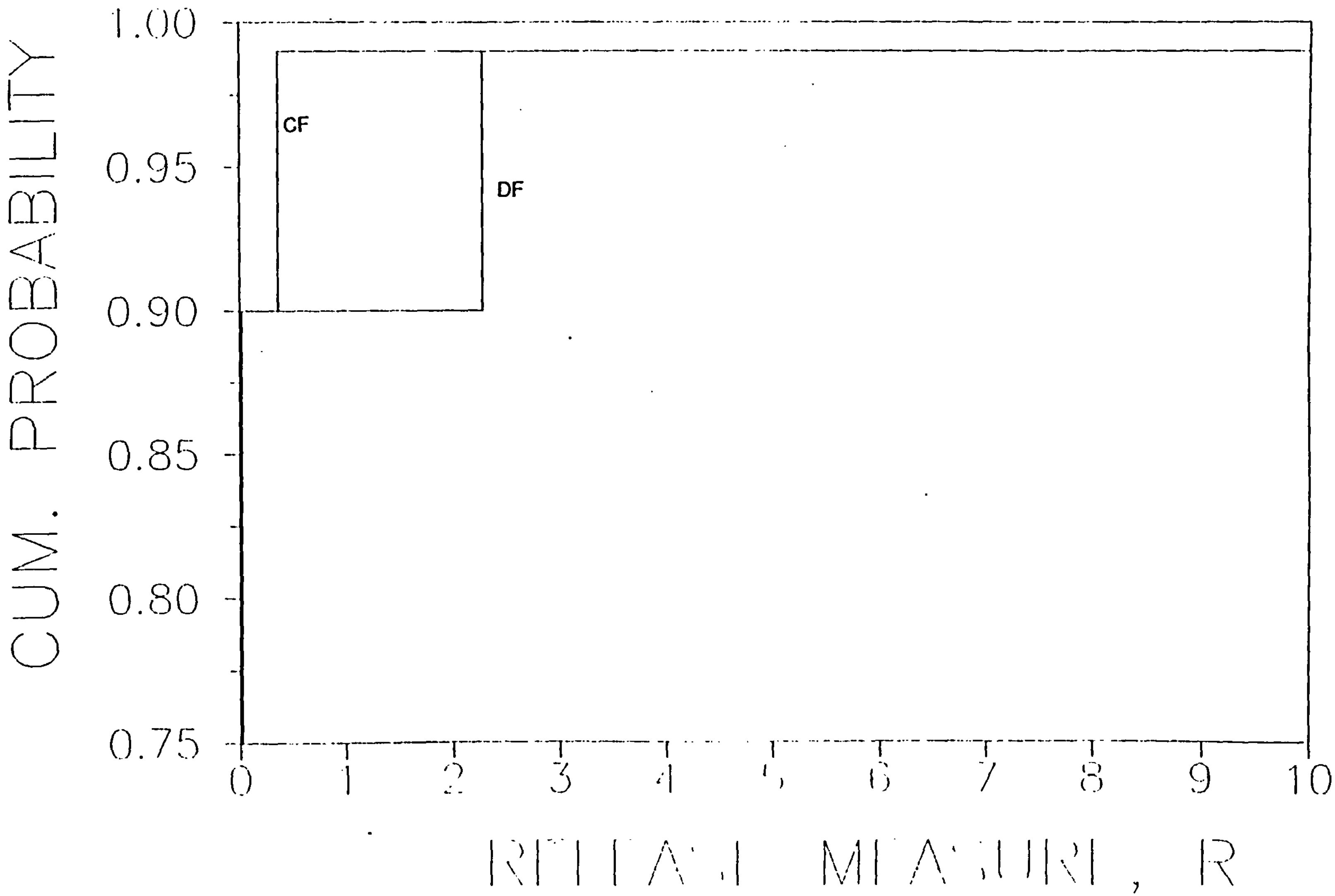
TECHNICAL INPUTS

AVAILABLE INVENTORY FOR CHn TRANSPORT

ASSESSED AQUEOUS RELEASES AVAILABLE AT THE TOP OF THE CHn OVER 10,000 YR FOR EACH FLOW REGIME

MAJOR INFLUENCE	DETAILS CONSIDERED
TOTAL FLUX	FLUX ASSOCIATED WITH FLOW REGIMES
WATER CONTACTING WASTE PACKAGE	DISTRIBUTION OF FLUX PRODUCED BY OVERLYING UNITS AND PROCESSES
WASTE FORM RELEASE	DEGREE OF CONSERVATISM FOR RELEASE FROM "FAILED" WASTE PACKAGES
RETARDATION IN EBS	EXTENT OF CONTAMINATED WATER FLOW THROUGH ENGINEERED MATERIALS
RADIONUCLIDE TRAVEL TIME IN THE HOST ROCK	PERCHED WATER BELOW REPOSITORY

CDF'S ON "AVAILABLE INVENTORY" FOR CHn TRANSPORT



TECHNICAL INPUTS

RELEASES FROM THE CHn UNIT

GIVEN AN INVENTORY OF RADIONUCLIDES TRANSPORTED TO THE CHn UNIT (REPRESENTED BY A VALUE FOR R), WHAT INVENTORY IS TRANSPORTED TO THE WATER TABLE IN 10,000 YR?

MAJOR INFLUENCE	DETAILS CONSIDERED
MINERALOGY/HYDRAULIC PROPERTIES	CHn FACIES DISTRIBUTION
FRACTURE–MATRIX DISTRIBUTION OF FLOW	FAULT ZONES MAY HAVE "TIGHT" ZONES WHERE MATRIX FLOW OCCURS
GEOHYDROLOGIC FRAMEWORK	FLOW PATHS WILL BE EXTENDED BY LATERAL DIVERSION AND HETEROGENEOUS DISTRIBUTION FOR MATRIX PROPERTIES
	VARIATION OF CHn THICKNESS
MATRIX DIFFUSION EFFECTS	DEGREE OF CONSERVATISM FOR RETARDATION OF MOBILE SPECIES

TECHNICAL INPUTS

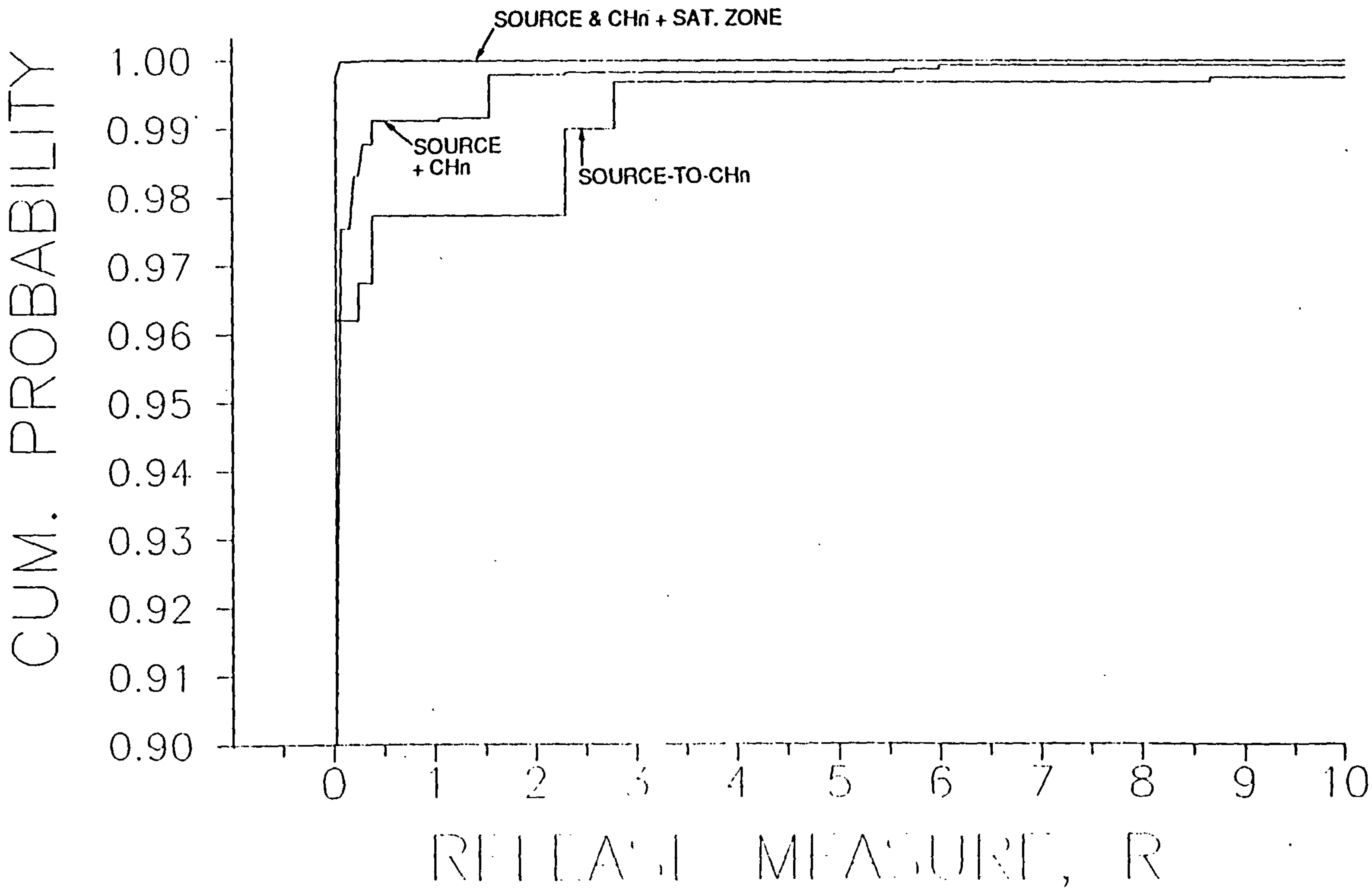
SATURATED ZONE TRANSPORT

ASSESS RELEASE REDUCTION FACTOR FOR TRANSPORT THROUGH THE SZ FROM THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT

- ANY LEVEL OF RELEASED INVENTORY
- ANY FLOW REGIME

MAJOR INFLUENCE	DETAILS CONSIDERED
GEOHYDROLOGIC FRAMEWORK	CHANGE IN AQUIFER TRANSMISSIVITY WITH WATER TABLE RISE
EFFECTIVE POROSITY	SCP POROSITY VALUES ARE CONSERVATIVE ALLOWING FOR LITTLE FRACTURE–MATRIX INTERACTION
RETARDATION IN SZ	MORE EXTENSIVE EXPERIENCE WITH SATURATED vs UNSATURATED CONDITIONS
MATRIX DIFFUSION	5 KM PATHWAY IS LONG ENOUGH TO PRESENT OPPORTUNITIES FOR MATRIX DIFFUSION

CDF'S FOR RELEASES FROM DIFFERENT COMPONENTS OF THE TOTAL SYSTEM
AGGREGATED OVER ALL FLOW REGIMES



TECHNICAL INPUTS

WASTE ISOLATION IMPACTS

ASSESS RELEASE–IMPACT FACTOR FOR EACH STRATEGY AND EACH FLOW REGIME; THE FACTOR MODIFIES RELEASES FROM THE CHn UNIT

(LEVEL OF IMPACTS ANALYSIS IN SCP SECTION 8.4.3)

MAJOR INFLUENCE	DETAILS CONSIDERED
FLUX IN UZ BETWEEN REPOSITORY AND WATER TABLE	SIGNIFICANT TRANSPORT ALONG BACKFILLED/SEALED OPENINGS REQUIRES WATER FLUX ALONG OPENINGS
PERCHED WATER BELOW REPOSITORY	NATURAL CONCENTRATING MECHANISM NEEDED FOR THE GREATEST POTENTIAL FLUX ALONG OPENINGS
GROUNDWATER FLOW TIME	UNSEALED, "LOST" BOREHOLE INTERSECTING PERCHED WATER MAY BE THE LARGEST IMPACT
GEOHYDROLOGIC FRAMEWORK	PLAN AREA AND SIZE OF OPENINGS ARE SMALL COMPARED TO CORRESPONDING DIMENSIONS OF THE SITE AND CHn UNIT

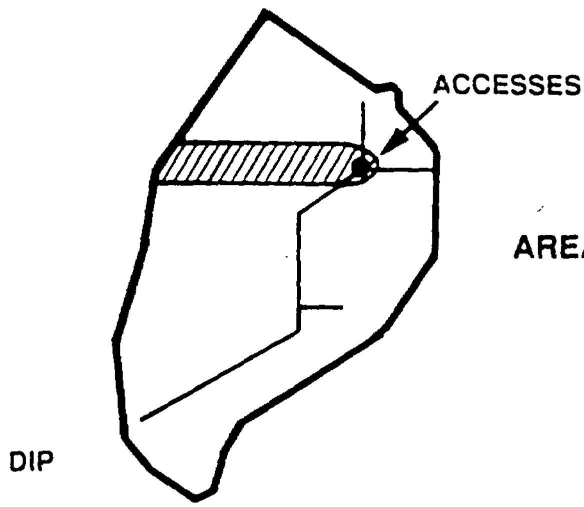
TECHNICAL INPUTS

WASTE ISOLATION IMPACTS

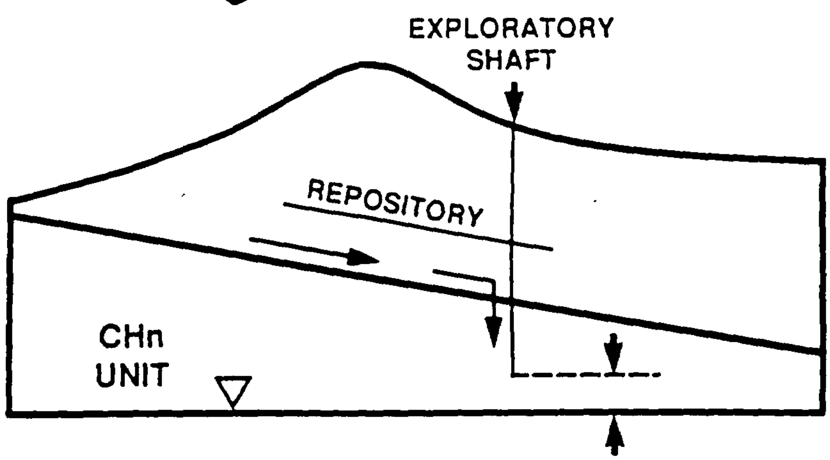
(CONTINUED)

MAJOR INFLUENCE	DETAILS CONSIDERED
FRACTURE–MATRIX DISTRIBUTION OF FLOW	DIVERSION OF GROUNDWATER FROM NATURAL PATHWAYS INTO ENGINEERED MATERIALS MAY IMPROVE PERFORMANCE
	ROCK MASS EXCAVATION DAMAGE WILL BE LIMITED IN NONWELDED TUFF
MOISTURE CONTENT	WATER USED IN CONSTRUCTION AND TESTING WILL QUICKLY DIFFUSE AND REMAIN NEAR OPENINGS IN NONWELDED TUFF
	VENTILATION OF DRIFTS WILL REMOVE SIGNIFICANT AMOUNTS OF WATER FROM THE WALL ROCK
PRECIPITATION, COLLOID EFFECTS, AND SORPTION COEFFICIENTS	FLUIDS/MATERIALS IMPORTED BY CONSTRUCTION/TESTING ARE LIKELY TO REMAIN NEAR THE UNDERGROUND OPENINGS

(STRATEGY #2 OR 5)
NATURALLY CONCENTRATED FLOW



$$\text{AREA RATIO} = \frac{\text{UPDIP TRAINED AREA}}{\text{TOTAL REPOSITORY AREA}} < 0.01$$



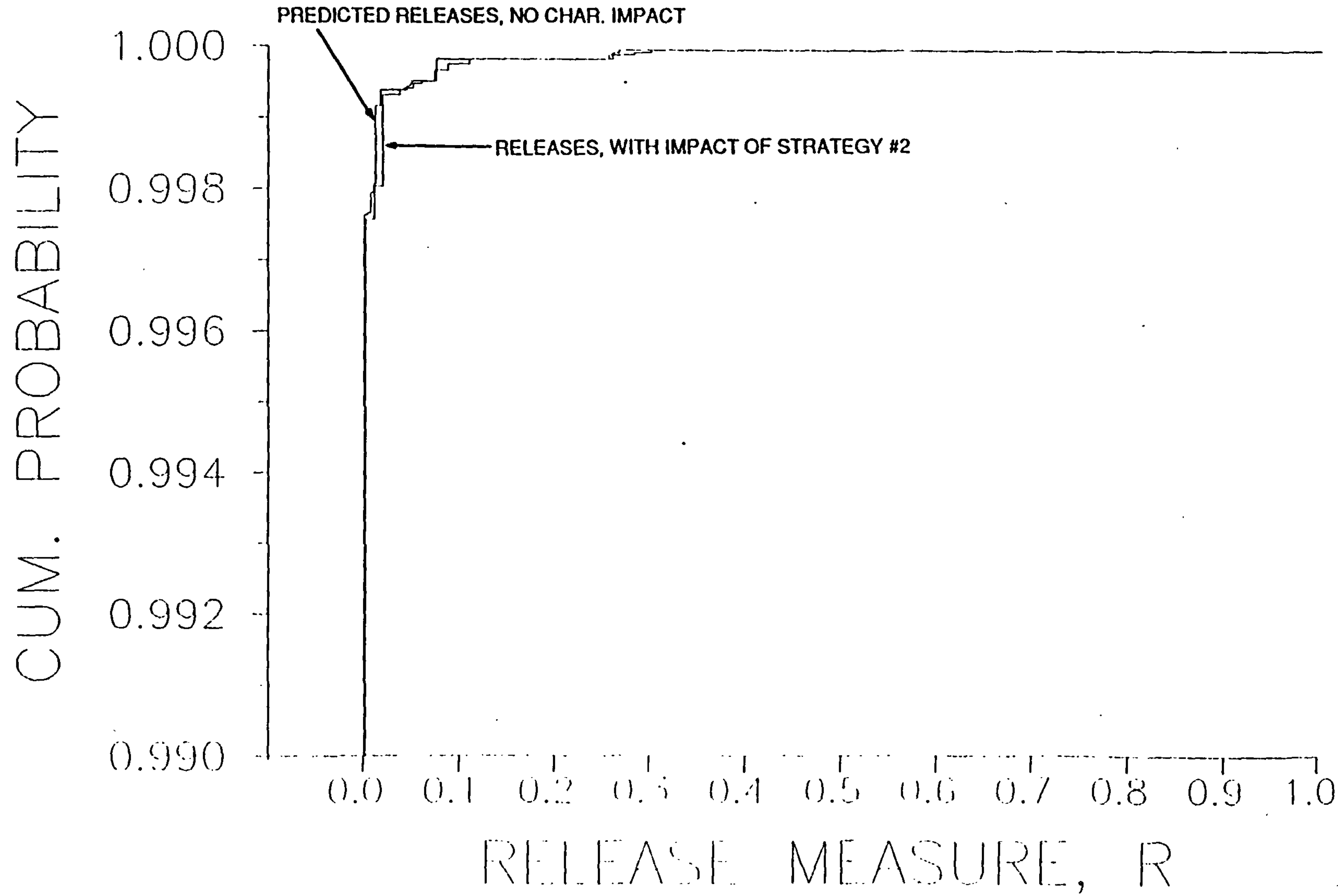
$$\text{TRAVEL TIME RATIO} = \frac{\left(\frac{\text{UNIT THICKNESS}}{\text{ROCK } k_{SAT}}\right)}{\left(\frac{\text{UNDISTURBED THICKNESS}}{\text{ROCK } k_{SAT}} + \frac{\text{DISTURBED THICKNESS}}{\text{BACKFILL } k_{SAT}}\right)} < 5$$

MULTIPLIER ON RELEASES: 1+ (AREA RATIO)(TRAVEL TIME) < 1.05

APPROXIMATE, CONSERVATIVE ESTIMATE FOR MULTIPLIER ON RELEASES FROM THE CHn

CDF'S FOR RELEASES FROM THE TOTAL SYSTEM

WITH AND WITHOUT IMPACT FROM STRATEGY #2



TECHNICAL INPUTS

EXPECTED TOTAL SYSTEM RELEASES AND WASTE ISOLATION IMPACTS

EXPECTED RELEASES, $R = 1.5 \times 10^{-4}$
(NO CHARACTERIZATION IMPACT)

STRATEGY #	DESCRIPTION	ΔR	$\frac{\Delta R}{R}$
2 (OR 5)	EXTENSIVE, INSIDE	2.0×10^{-5}	13%
1	EXTENSIVE, OUTSIDE SE, + LIMITED, INSIDE NE, + SBT	4.7×10^{-6}	3%
3	LIMITED, INSIDE NE	4.2×10^{-6}	3%
4	LIMITED, INSIDE S	3.5×10^{-6}	2%
6	SBT	3.0×10^{-6}	2%
7	EXTENSIVE, OUTSIDE SE, + SBT	1.6×10^{-7}	<1%
8	LIMITED, OUTSIDE SE, + SBT	1.3×10^{-7}	<1%

SUMMARY OF TECHNICAL INPUT

- STRATEGIES 2 (OR 5) HAVE SIGNIFICANTLY HIGHER LIKELIHOODS OF PRODUCING CORRECT RESULTS
- TOTAL SYSTEM RELEASES ARE EXPECTED TO BE > 1,000 TIMES LESS THAN THE THRESHOLD LEVEL USED IN THE PROBABILISTIC EPA STANDARD
- THE CHANGE IN TOTAL SYSTEM RELEASES AS A RESULT OF EXTENSIVE CHARACTERIZATION INSIDE THE BLOCK IS EXPECTED TO BE A SMALL FRACTION OF TOTAL RELEASES