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 - SATURATED ZONE MODEL

PRESENTER: JACK ROBERTSON

PRESENTER'S TITLE AND ORGANIZATION: EXECUTIVE VICE PRESIDENT
HYDROGEOLOGIC, INC.

PRESENTER'S TELEPHONE NUMBER: (703) 478-5186

DENVER, COLORADO
MARCH 6-7, 1991

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 - SATURATED ZONE MODEL

PRESENTER: JACK ROBERTSON

PRESENTER'S TITLE AND ORGANIZATION: EXECUTIVE VICE PRESIDENT
HYDROGEOLOGIC, INC.

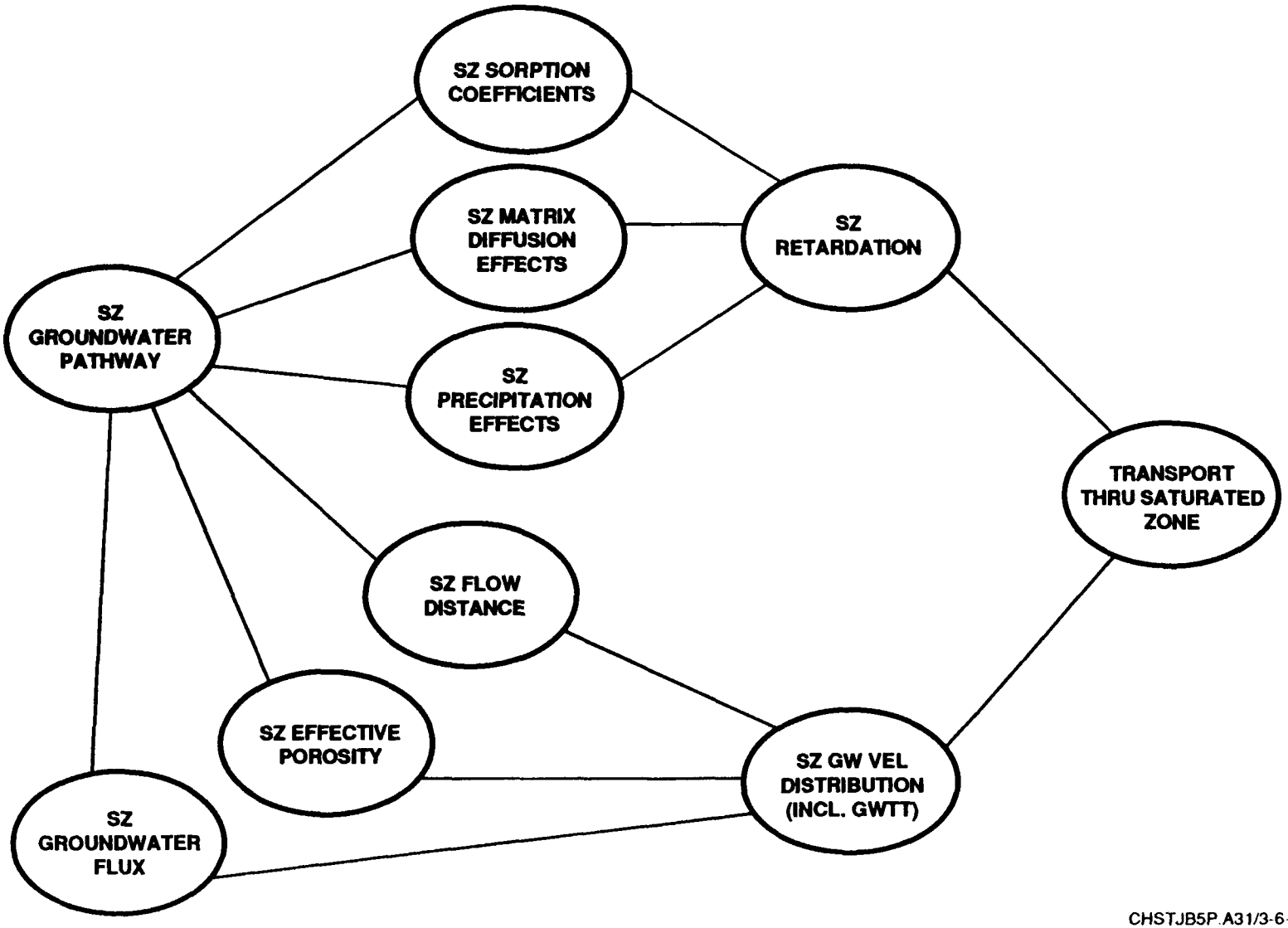
PRESENTER'S TELEPHONE NUMBER: (703) 478-5186

DENVER, COLORADO
MARCH 6-7, 1991

SATURATED ZONE PERFORMANCE INTRODUCTION

- MULTIPLE BARRIER CONCEPT
- STATE OF KNOWLEDGE, SZ
  - FEW DATA
  - SCP CONSERVATIVE TRAVEL-TIME ESTIMATE
- CHRBA APPROACH TO SZ ASSESSMENT
  - REALISTIC BEST ESTIMATES
  - SORPTION/MATRIX DIFFUSION EFFECTIVE
  - RELEASE REDUCTION FACTOR, 10K YR
  - CUMULATIVE DISTRIBUTION PERCENTILES, 99, 90, 50 AND 10

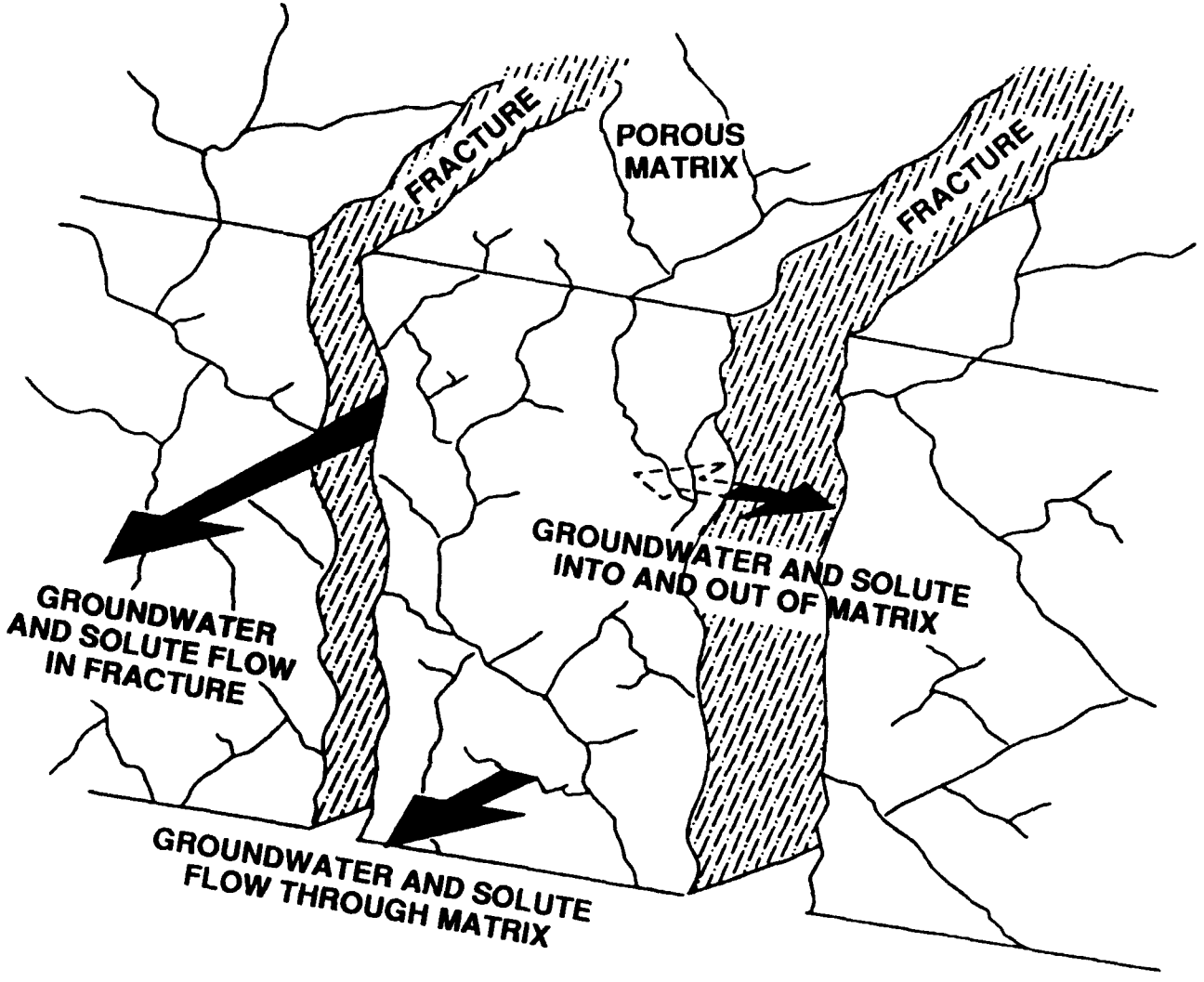
SATURATED ZONE PERFORMANCE INFLUENCE DIAGRAM



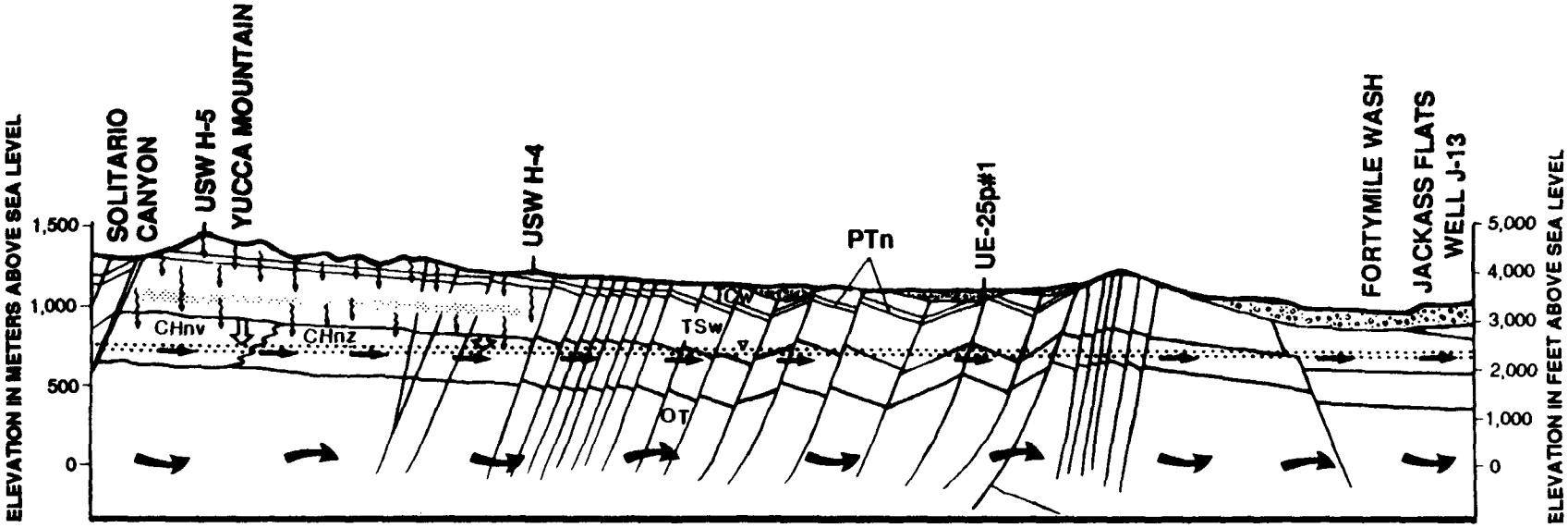
SATURATED ZONE CONSIDERATIONS BY CHRBA

- FLAT LATERAL GRADIENT
- UPWARD GRADIENT
- MOST OF PATHWAY IN CHnz
- FRACTURE PERMEABILITY AND FREQUENCY
- HYDRAULIC CONDUCTIVITY DECLINES WITH DEPTH
- HIGH BULK POROSITY
- HIGH ION EXCHANGE CAPACITY
- MUCH OF POROSITY PARTICIPATES IN FLOW AND TRANSPORT
- SMALL EFFECTS FROM CLIMATIC CHANGE

GROUNDWATER AND SOLUTE FLOW AND DIFFUSION IN FRACTURED POROUS MEDIA



CONCEPTUAL HYDROGEOLOGIC SECTION



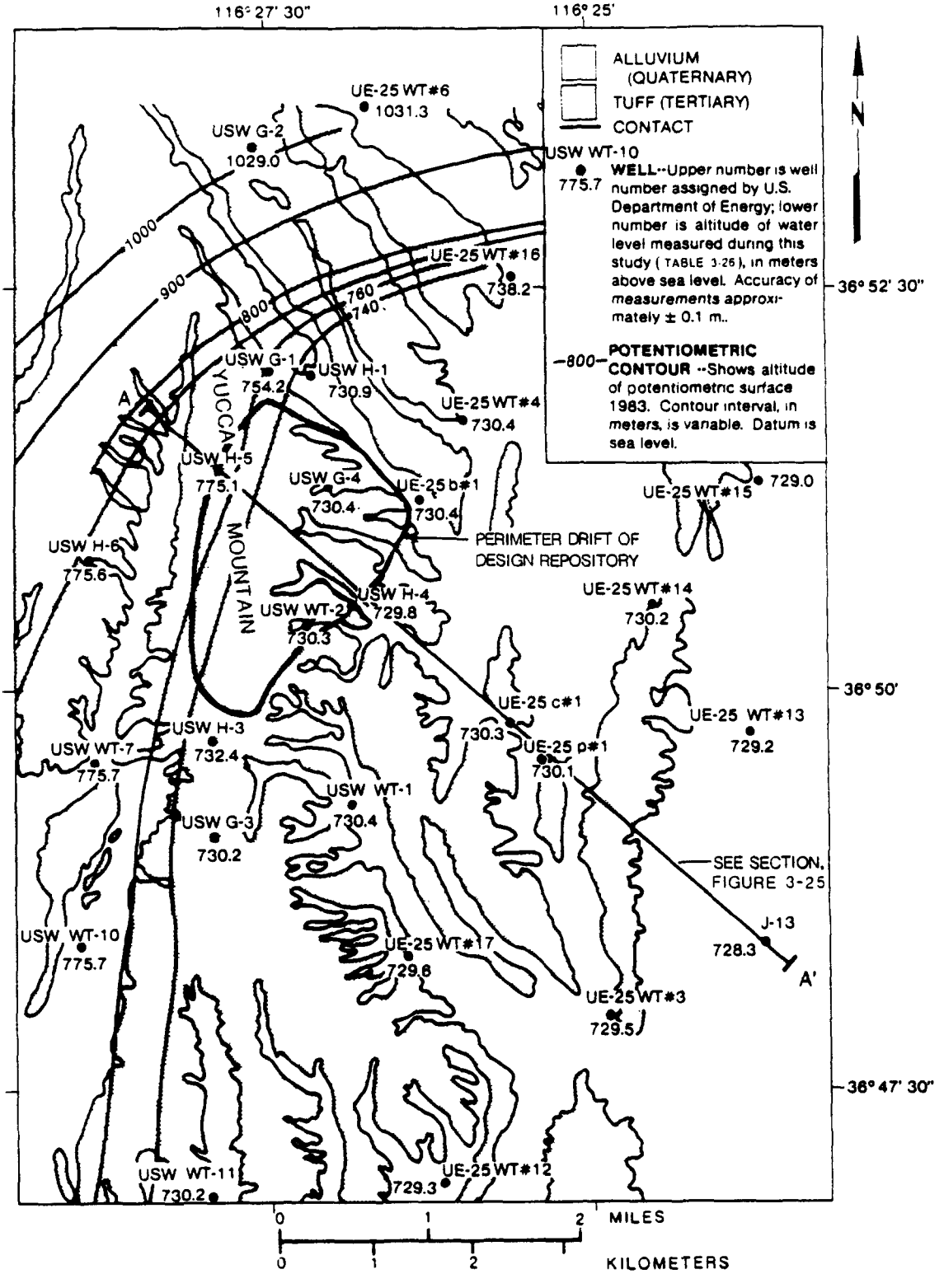
- ALLUVIUM & TIMBER MOUNTAIN TUFF
- DESIGN REPOSITORY (THICKNESS EXAGGERATED)
- WATER TABLE
- FLUX THROUGH THE UNSATURATED ZONE
- UNSATURATED-ZONE FLOW PATHS USED FOR TRAVEL TIME CALCULATIONS
- SATURATED-ZONE FLOW PATH FOR WATER THAT HAS PASSED THROUGH THE REPOSITORY LEVEL
- DEEP SATURATED-ZONE FLOW PATHS FOR WATER THAT HAS NOT PASSED THROUGH THE REPOSITORY LEVEL

TCw	TIVA CANYON WELDED UNIT
PTn	PAINTBRUSH NONWELDED UNIT
TSw	TOPOPAH SPRING WELDED UNIT
CHnv	CALICO HILLS NONWELDED VITRIC UNIT
CHnz	CALICO HILLS NONWELDED ZEOLITIC UNIT
OT	OLDER TUFF UNIT

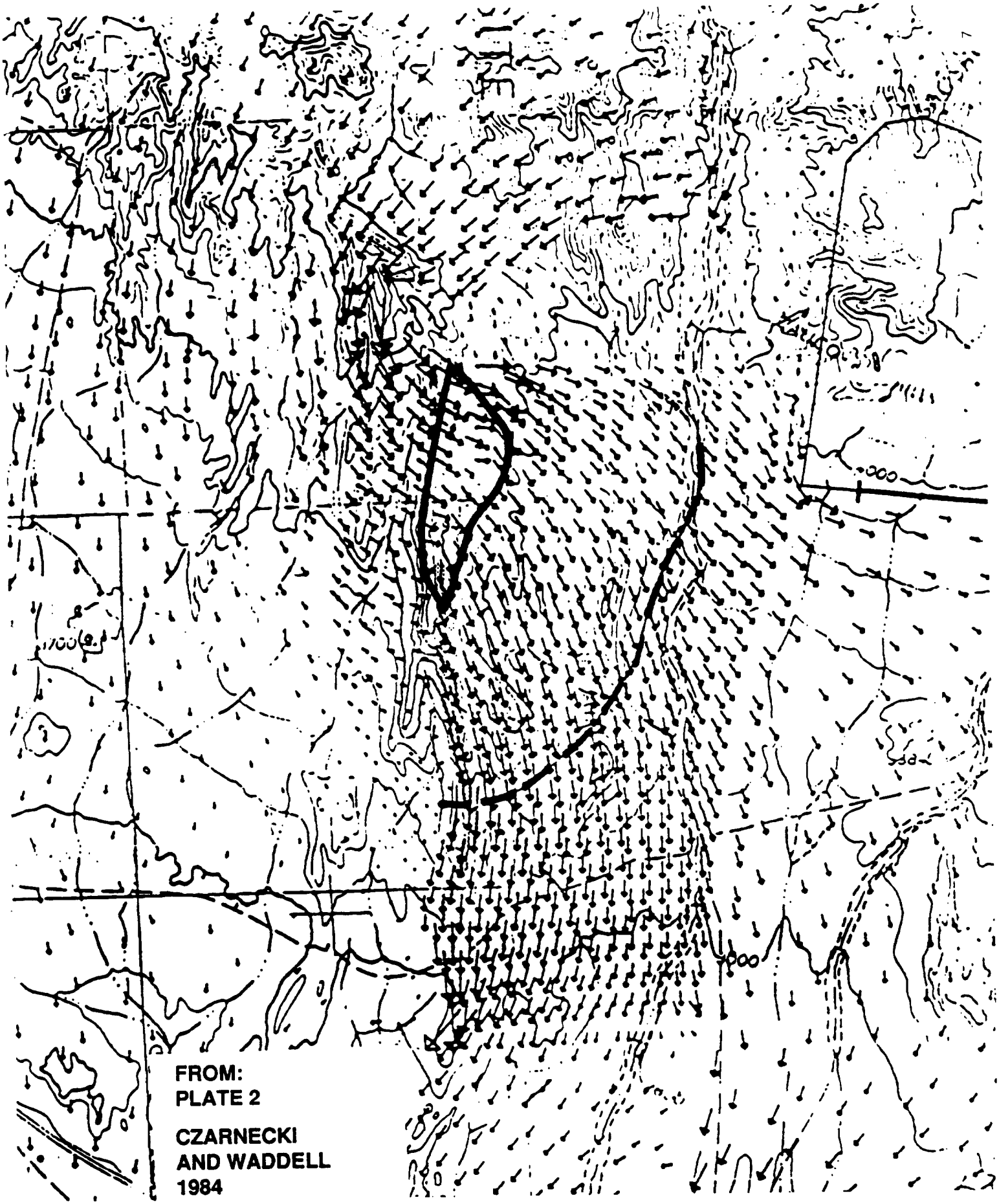
0 0.5 1 MILES

0 0.5 1 KILOMETERS

PRELIMINARY COMPOSITE POTENTIOMETRIC-SURFACE MAP OF THE SATURATED ZONE



[From U S. Department of Energy Site Characterization Plan, 1988, Figure 3-28 (modified from Robison, 1984 Robison, 1986).]



FROM:
PLATE 2

CZARNECKI
AND WADDELL
1984

ESTIMATES OF RELEASE REDUCTION FACTOR REPRESENTING THE PERFORMANCE OF THE SATURATED ZONE PATHWAY (SIX CHRB PANELISTS)

PROBABILITY LEVEL	GEOMETRIC AVERAGE REDUCTION FACTOR	ARITHMETIC AVERAGE REDUCTION FACTOR
0.99	0.053	0.23
0.90	1.0×10^{-3}	0.019
0.50	4.6×10^{-6}	1.7×10^{-3}
0.10	1.5×10^{-9}	1.7×10^{-4}

POROSITY OF YUCCA MOUNTAIN TUFFS

TUFF UNIT	BULK TOTAL POROSITY, %	SATURATED EFFECTIVE POROSITY, %	BASIS	REF.
TOPOPAH SPRING	15 ± 5	8-12	CORE TESTS AND ESTIMATE	1
CALICO HILLS VITRIC	39 ± 8	20-30	CORE TESTS AND ESTIMATE	1
CALICO HILLS ZEOLITIC	30 ± 9	10-20	CORE TESTS AND ESTIMATE	1
		20	ESTIMATE	2
OTHERS	23 ± ?	5-15	CORE TESTS AND ESTIMATE	1

REFERENCES: 1) SINNOCK et al., 1987
2) BARR AND MILLER, 1987

BULK SATURATED HYDRAULIC CONDUCTIVITY/TRANSMISSIVITY, YUCCA MOUNTAIN TUFFS

TUFF UNIT	MATRIX	BULK	BASIS	REF.
TOPOPAH SPRING	3.5×10^{-9}	1×10^{-3}	CORE; WELL;	1
		5.7×10^{-5}-6.1×10^{-3}	WELL EST.	3
		8.1×10^{-4}	WELL	4
CALICO HILLS VITRIC	1.3×10^{-6}	2.4×10^{-4}	CORE; WELL	1
CALICO HILLS ZEOLITIC	4.2×10^{-9}	2.4×10^{-4}	CORE; WELL	1
	5×10^{-9}-3.5×10^{-7}	6×10^{-4}	CORE; WELL	4
		4.2×10^{-3}	MODEL	2
		1×10^{-3}	WELL	6
PROW PASS/ CRATER FLAT		2.3×10^{-6}-1.6×10^{-3}	WELL	4,6
OTHER	1.1×10^{-7}	4×10^{-4}-1×10^{-3}	CORE; WELL	1
		4.5×10^{-6}-4.2×10^{-3}	MODEL	2

TRAVEL TIME ESTIMATES BY OTHERS

CZARNECKI AND WADDELL (1984)	100 - 20,000 YRS [1]
SCP	170 YRS [1] [2]

[1] ASSUMES NO MATRIX DIFFUSION EFFECT

[2] ASSUMES FRACTURE FLOW ONLY (NO MATRIX FLOW)

ESTIMATED GROUND WATER AGES (C-14)

APPARENT AGE	COMMENT	REFERENCE
7,300 - 2,400 YR	AMARGOSA VALLEY	CLAASSEN, 1985
9,100 - 17,000 YR	YUCCA MOUNTAIN	CLAASSEN, 1985
2,280 - 17,000 YR	YUCCA MOUNTAIN	WADDELL et al., 1984
14,600 - 18,500 YR	YUCCA MOUNTAIN WELL USWH-6	BENSON AND McKINLEY, 1985

TRAVEL TIME CALCULATION

GRADIENT (WELL H-4 TO WELL J-13) = 2.7×10^{-4}
(WELL USWWT-2 TO UE25WT#3) = 1.6×10^{-4}

K = 0.1 TO 1 m/d

EFFECTIVE POROSITY = 0.05 TO 0.3 (ALLOWING FOR MATRIX DIFFUSION)

VELOCITY = 5.4×10^{-3} m/d
TO
5.3×10^{-5} m/d

TRAVEL TIME FOR 5 km: 2,500 TO 260,000 YRS.

USING TYPICAL VALUES: (GRAD = 2×10^{-4}, K = 0.2, POROS = 0.15)

V = 2.7×10^{-4} m/d
TT = 50,000 YRS.

SUMMARY ASSESSMENT OF SATURATED ZONE EXPECTED PERFORMANCE

- LOW GRADIENT AND PERMEABILITY PLUS HIGH POROSITY CAUSE SLOW TRAVEL TIMES
- MATRIX DIFFUSION AND ION EXCHANGE CAUSE HIGH RETARDATION EFFECTS
- RELEASE REDUCTION FACTORS
  10^{-3} - 10^{-2} @ 90%
  10^{-6} - 10^{-3} @ 50%
- SZ VERY SIGNIFICANT POTENTIAL BARRIER
- RELATIVE IMPORTANCE OF CHn DIMINISHED BY SZ PERFORMANCE

REFERENCES

1) SINNOCK, et. al., 1987
2) CZARNECKI, 1985
3) SCP, TABLE 3-8, 1988
4) SCP, TABLE 3-27, 1988
5) BARR AND MILLER, 1987
6) CRAIG AND ROBISON, 1984