

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

NUCLEAR WASTE TECHNICAL REVIEW BOARD

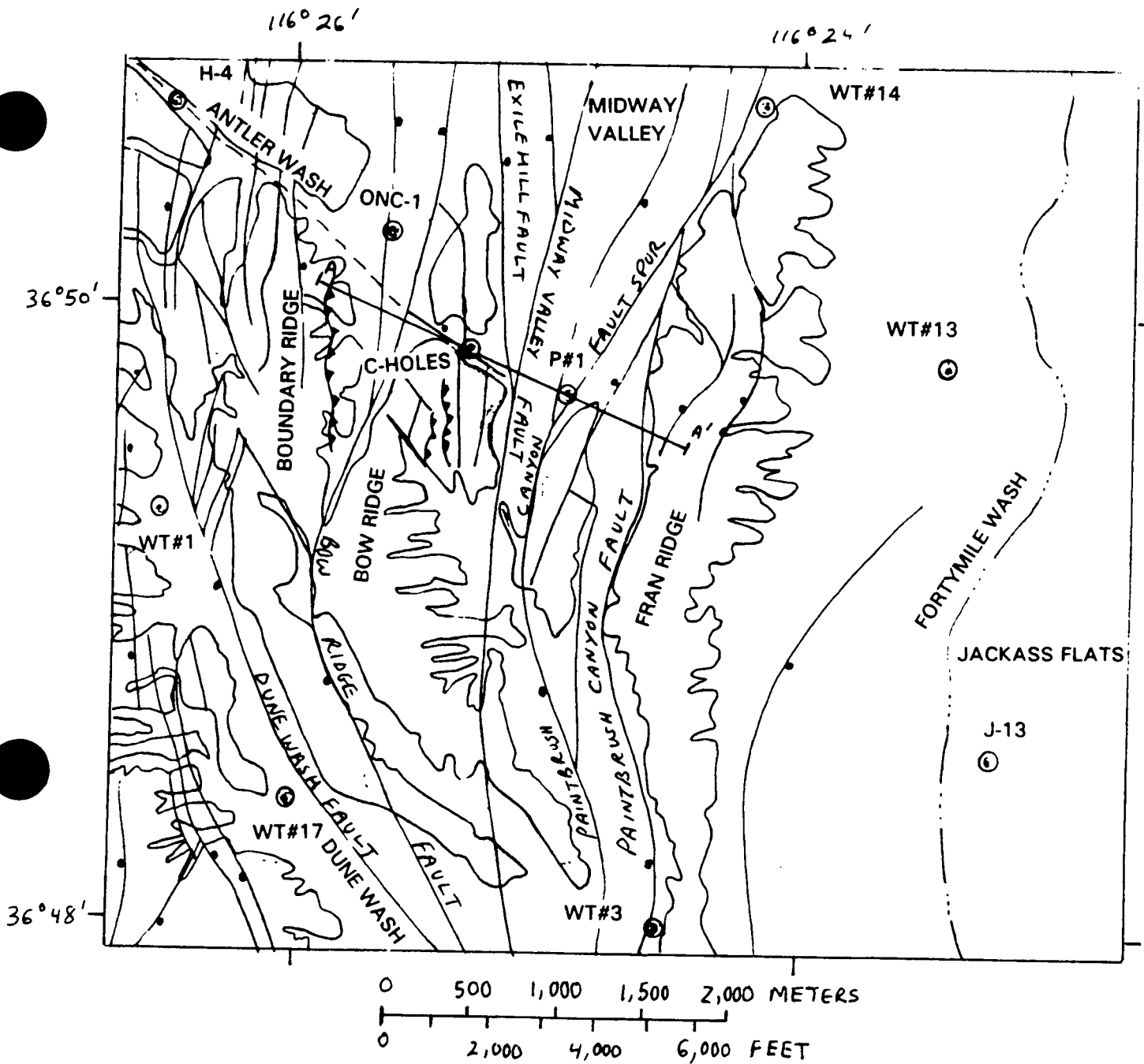
**SUBJECT: HYDRAULIC AND
CONSERVATIVE TRACER TESTING
AT C-WELLS COMPLEX**

PRESENTER: M. J. UMARI

**PRESENTER'S TITLE
AND ORGANIZATION: PRINCIPAL INVESTIGATOR
U.S. GEOLOGICAL SURVEY (USGS)
DENVER, CO**

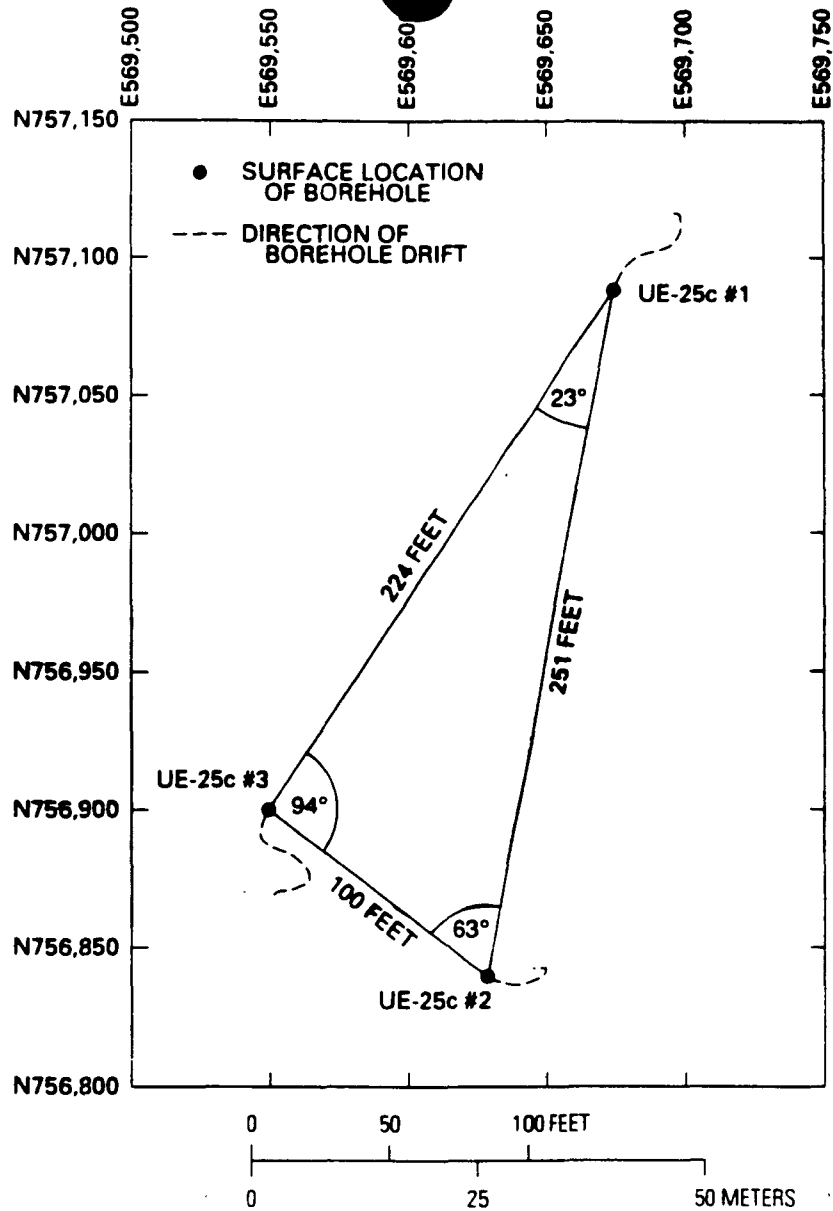
**TELEPHONE NUMBER: (303) 236-5050
EXT 247**

**PAHRUMP, NV
JANUARY 29, 1997**

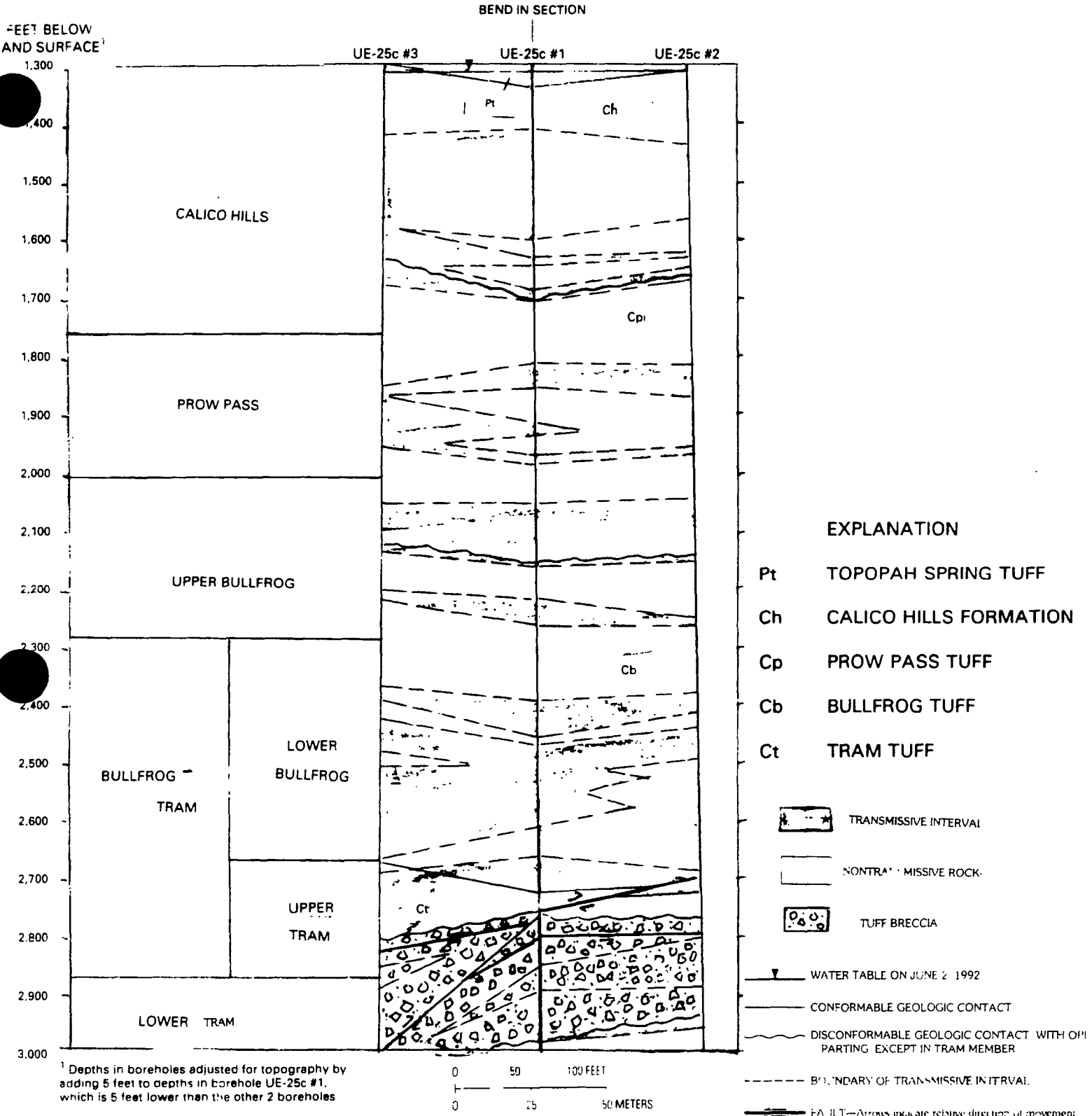


EXPLANATION		BOREHOLE ABBREVIATIONS	
	ALLUVIUM	WT#1	USW WT#1
	MIOCENE TUFFACEOUS ROCKS	WT#3	UE-25 WT#3
	P#1 BOREHOLE	WT#13	UE-25 WT#13
	GEOLOGIC CONTACT	WT#14	UE-25 WT#14
	FAULT TRACE -- Dashed where Inferred; ball on downthrown side of normal fault; teeth on upthrown side of reverse fault	WT#17	UE-25 WT#17
A — A'	HYDROGEOLOGIC SECTION SHOWN IN FIGURE 3	ONC-1	UE-25 ONC-1
		H-4	USW H-4
		P#1	UE-25 p#1

Generalized geologic map showing the location of the C-hole complex and nearby boreholes (Geology modified from Day and others, in press).



Surface location and drift of boreholes UE-25 c#1, UE-25 c#2, and UE-25 c#3 (Map referenced to Nevada State, Zone 2, coordinates)

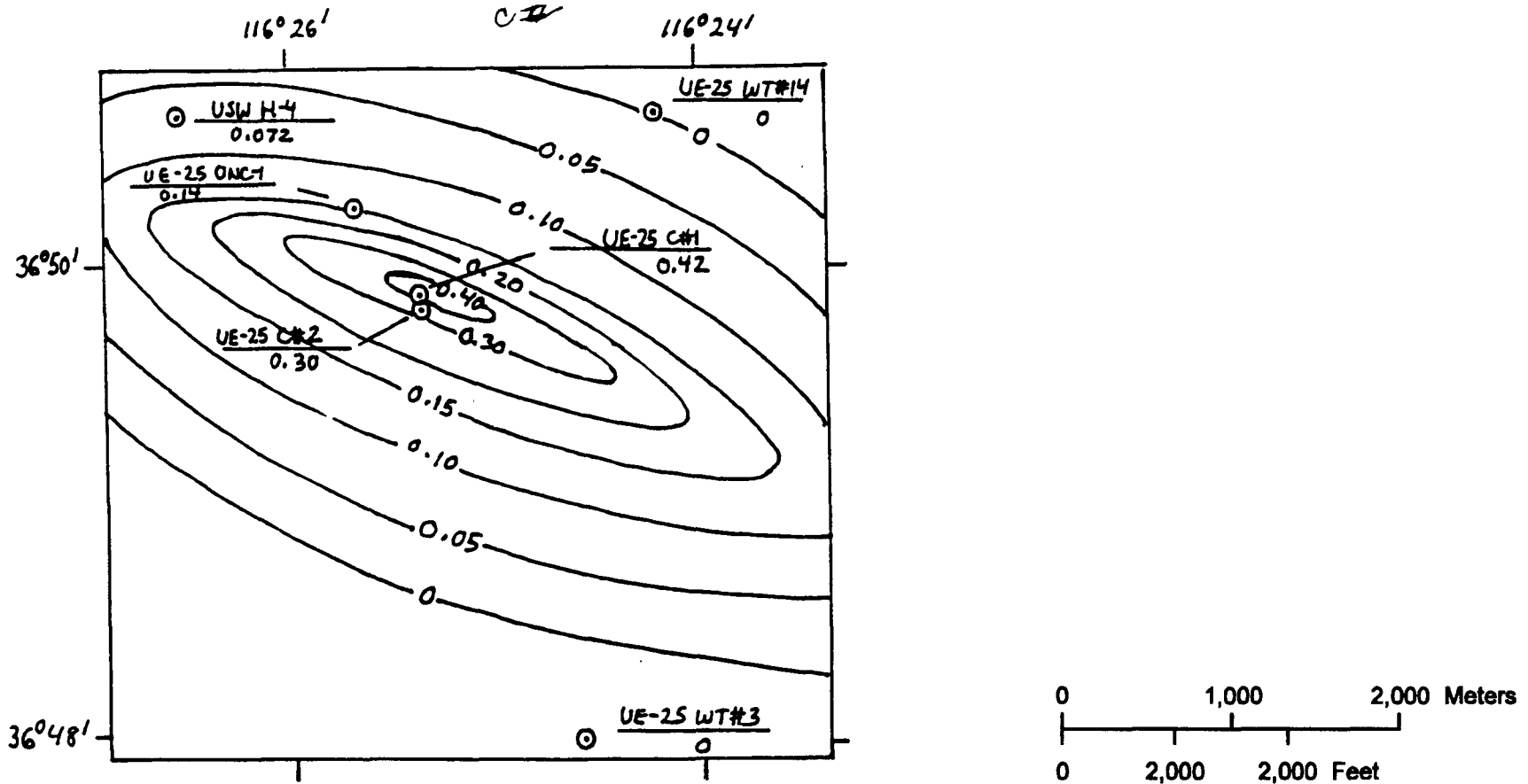


Hydrogeologic intervals delimited by packer placement in the C-holes, June 1995 to August 1996

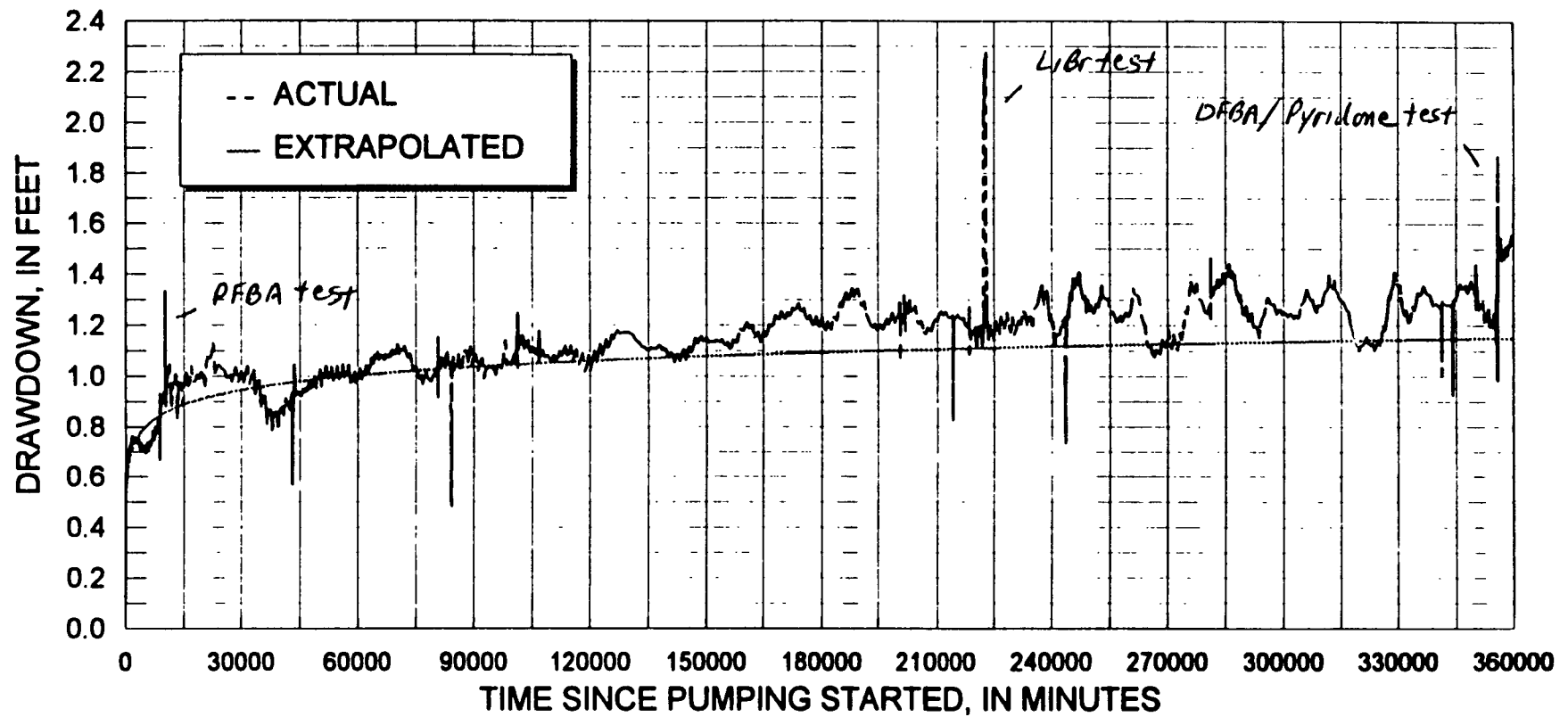
Hydraulic Tests

- **5/95** **Open-Hole**
- **6/95** **Open-hole in pumping well, packed off in observation wells**
- **2/96** **In Bullfrog-Tram**
- **5/96** **In Lower Bullfrog**
- **5/96** **To present: Long-term test**

Drawdown in the vicinity of Borehole UE-25 c#3, 14,000 minutes after pumping started, pumping test in Borehole UE-25 c#3, May-June 1995



Explanation	
— 0.10 —	Line of equal drawdown -- Interval, in meters, is variable
<u>USW H-4</u> 0.072	⊙ BOREHOLE - Borehole numbers above line; drawdown, in meters, below line



UE-25 C#2 DRAWDOWN, MAY 1996 - JANUARY 1997

Results of Hydraulic Testing

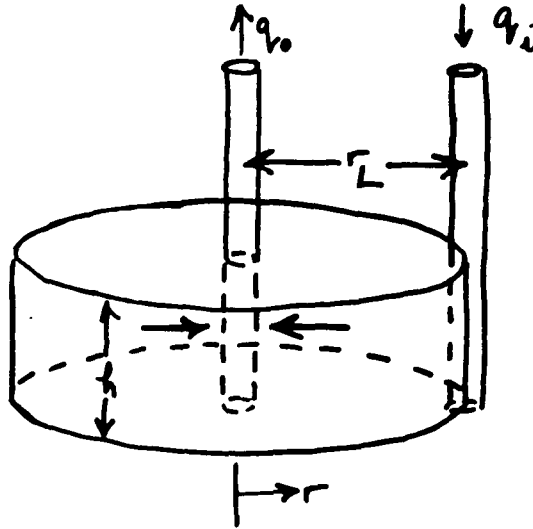
Unit	T (ft ²/day)
• Calico Hills	200-1,000
• Prow Pass	400-800
• Upper Bullfrog	400-3,600
• Lower Bullfrog	18,000-26,000
• Upper Tram	6,000-8,000
• Composite	18,000-32,000

**Photograph of C-Holes Complex
showing injection pipes for tracers**

Tracer Tests

- **2/13/96 Test with c#3 as pumping well and iodide injected in c#2 in convergent flow field (Combined Bullfrog-Tram)**
- **1/10/97 Test, similar flow field, Pyridone injected into c#1 and 2,6 di-fluoro benzoic acid (DFBA) injected into c#2 (Bullfrog)**
- **Planned Prow Pass test**

Moench Analytic Solution to Advection Dispersion Equation



$$PE = \frac{r_L}{\alpha_L} \quad ; \quad L_a = \frac{\pi h \phi_f (r_L^2 - r_w^2)}{q_o}$$

$$\gamma(\text{GAMMA}) = \gamma(\Delta_M, 1 - \phi_f, \frac{1}{b^2}, q_o^{-1}, h, r_L^2 - r_w^2)$$

$$\Gamma(\text{SIGMA}) = \Gamma\left(\frac{\phi_M}{\phi_f / (1 - \phi_f)}\right)$$



input file path

c:\labview\rcv2_inp.000

Output file path

c:\labview\rcv2_out.000

Run by:

M.J. Umari

Plot 0

Results from Moench program

Results from 2/8/96-3/29/96 iodide test

fracture porosity
0.0068

Matrix porosity
0.0320

longitudinal
dispersivity (ft)
20.75

ROW 4

BIGT

30.00

METH

3

NN

40

FB(l)

ROW 6 1.00

Gamma(l)

ROW 7 10.00

Tophat t_inj (minutes)

296.00

Pumping rate (gpm)

117.00

Cl(mg/l)

0.5038

r_L(ft)

95.00

r_l(in)

5.50

r_w(in)

5.50

t_a(days)

5.14

mu

0.0068

epsilon

0.0031

Top hat C_o calc.

Mass (kg)

1.65

Inj.Vol.(gal)

2190.00

Co(mg/l)

199.0554

h (ft)

600.00

h_l (ft)

168.00

h_w(ft)

168.00

ROW 8

Sigma(l)

4.6739

ROW 9

SK(l)

0.0060

C (ppb) versus t (days)

110.0-

100.0

90.0-

80.0-

70.0-

60.0-

50.0-

40.0-

30.0-

20.0

10.0

0.0-

0.0

5.0

10.0

15.0

20.0

25.0

30.0

35.0

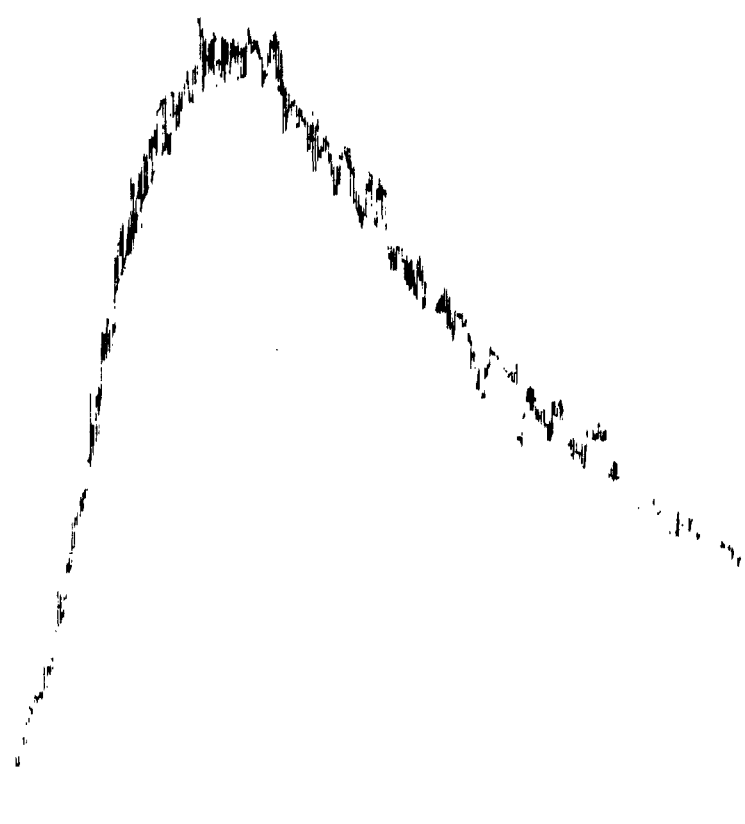
40.0

45.0

50.0

55.0

60.0



Plot 1

N	IQD	LOGT	NLC	NOX	TDFIRST	DELTD	TDP	XMUI	XMUW
ROW 5 1.00	1.00	ROW 0 1.000	2.000	30.000	ROW 1 0.300	0.000	0.040025	0.3121	0.1380
1: Dirac	INPTRA	NTS	KT	IFLUX	PE	RWD	RTARD	XMULT	
2: Tophat	ROW 2 2	10	4	0	ROW 3 4.58	0.0048	1.00	0.004	

Input file path

c:\labview\rcv2_inp.000

Output file path

c:\labview\rcv2_out.000

Run by: M.F.Fahy

Tophat t_{inj} (minutes)

Top hat C_o calc.

Plot 0

Results from Moench program

Plot 1

Results from 2/8/96-3/29/96 iodide test

fracture porosity

0.0866

Matrix porosity

0.1895

longitudinal dispersivity (ft)

8.68

C (ppb) versus t (days)

28.00

Mass (kg)

1.60

Pumping rate (gpm)

Inj. Vol. (gal)

117.00

6550.00

Cl (mg/l)

Co (mg/l)

0.1356

64.5376

r_L (ft)

h (ft)

95.50

168.00

r_I (in)

h_I (ft)

5.50

168.00

r_w (in)

h_w (ft)

5.50

168.00

a (days)

ROW 8

18.50

Sigma(l)

mu

2.00

0.0948

ROW 9

epsilon

SK(l)

0.0031

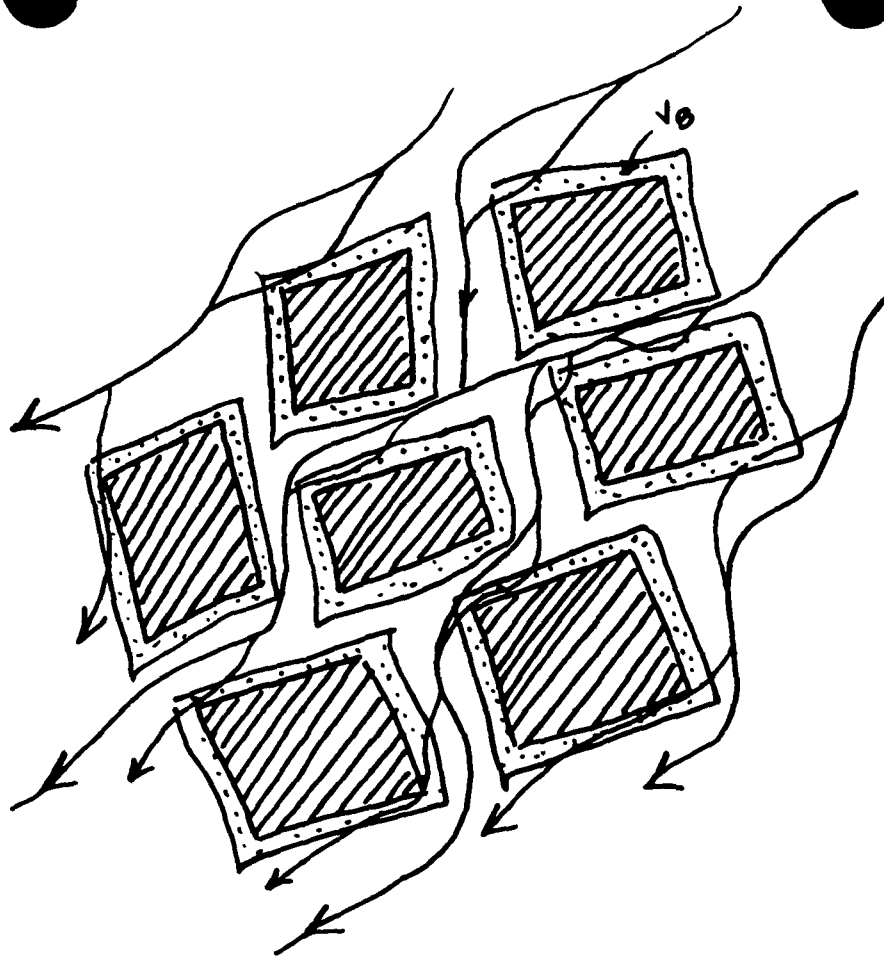
0.0060

110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0

0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0 55.0 60.0

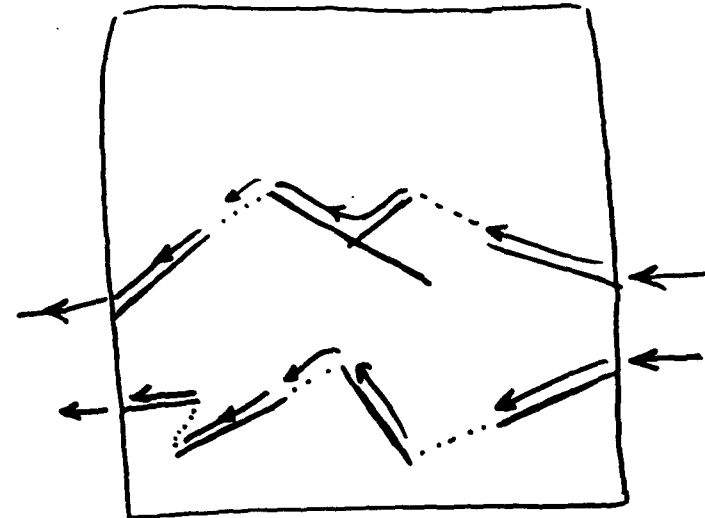
LOGT	NLC	NOX	TDFIRST	DELTD	TDPR	XMU	XMUW			
ROW 0	1.000	2.000	30.000	ROW 1	0.300	0.000	0.001051	0.0871	0.0383	
INPTRA	NTS	KT	IFLUX	PE	RWD	RTARD	XMULT			
1: Dirac										
2: Tophat	ROW 2	2	10	4	1	ROW 3	11.00	0.0048	1.00	0.040
RIGT	METH	NN		N	IQD		FB(l)		Gamma(l)	

9/2/96



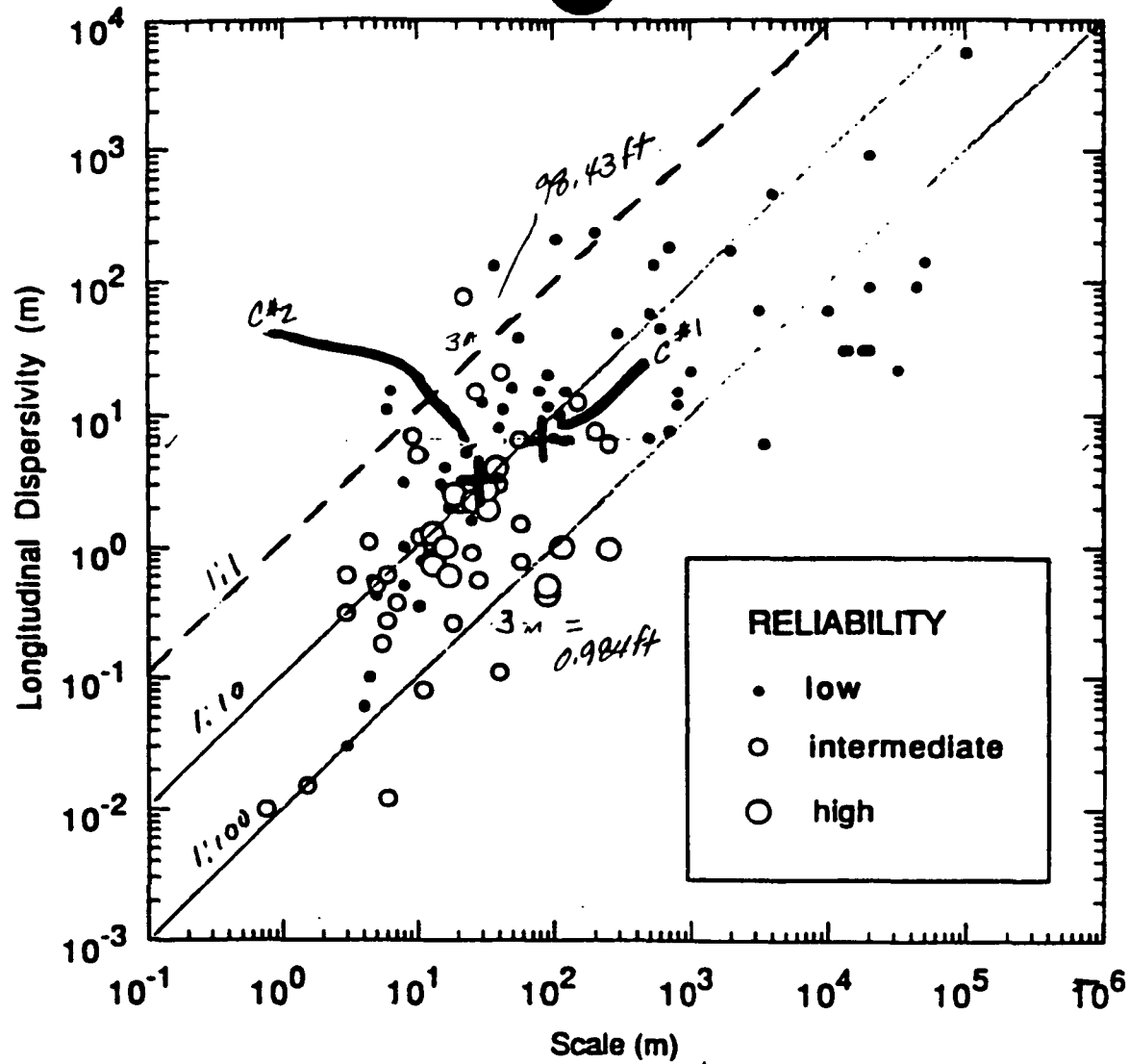
$$\phi_M|_{\text{EFF.}} = \frac{\sum V_B}{V} \ll \phi_M$$

Blocks with Boundary Layers



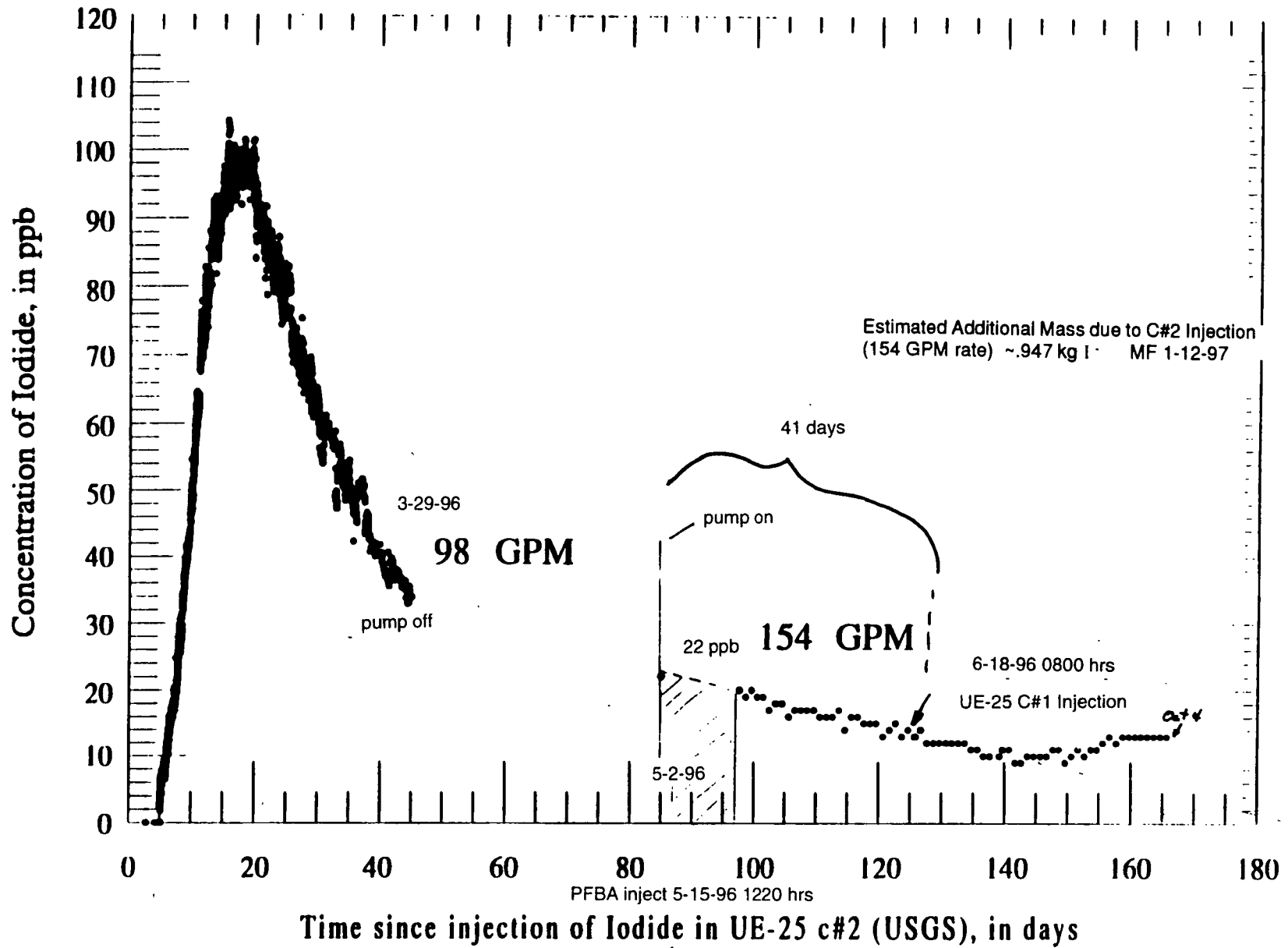
$$\phi_F|_{\text{EFF.}} \gg \phi_F$$

Discontinuous Fractures



	C1	C2 (new)
19' = 5.79m	23' = 7.13m	8.68' = 2.65m
100' = 30.48m	281' = 85.6m	96' = 29.26m

Combined UE-25 c#2 (USGS) and residual from LANL test



Results of Conservative Tracer Tests

- Fracture Porosity 0.0068-0.0866**
- Matrix Porosity 0.032 - 0.1895**
- Longitudinal Dispersivity 8.68 ft - 20.75 ft**

- Dual-porosity medium seems to be indicated by the data**
- Transport parameters less firm than hydraulic parameters**

Conclusions

- **High-flow zones at the C-wells complex have been successfully characterized for hydraulic and transport properties**
- **Results from hydraulic testing have provided information on hydraulic parameters at a scale larger than C-wells**
- **Success of testing at complex indicates that it should be used for additional testing**
 - 1) **Low-flow zone**
 - 2) **Fault zone at bottom of complex**

Planned Future Work

- **Conduct hydraulic and conservative tracer testing in a low-flow zone at the C-wells complex (Prow Pass)**
- **Conduct hydraulic and conservative tracer testing at other locations near Yucca Mountain**