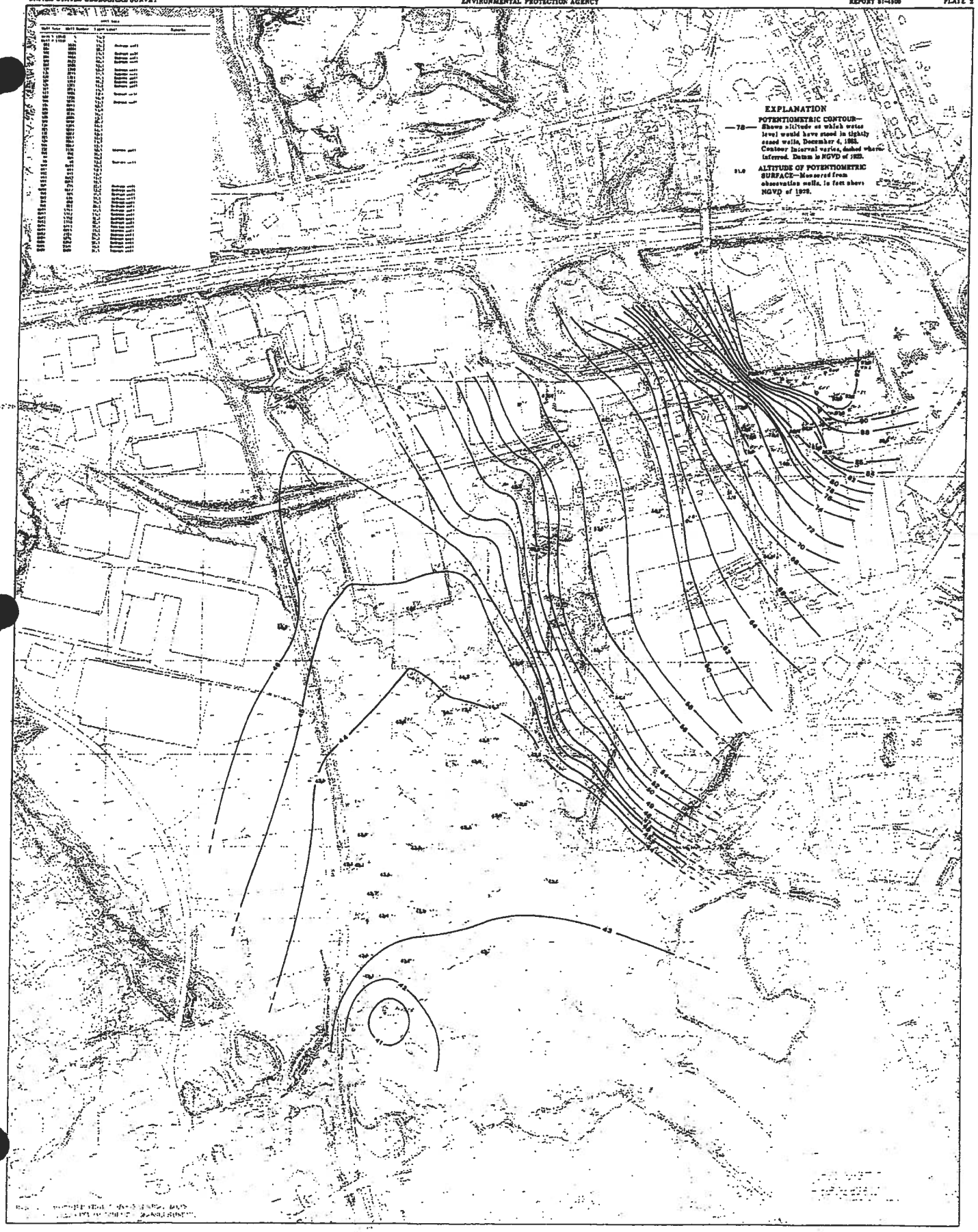
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

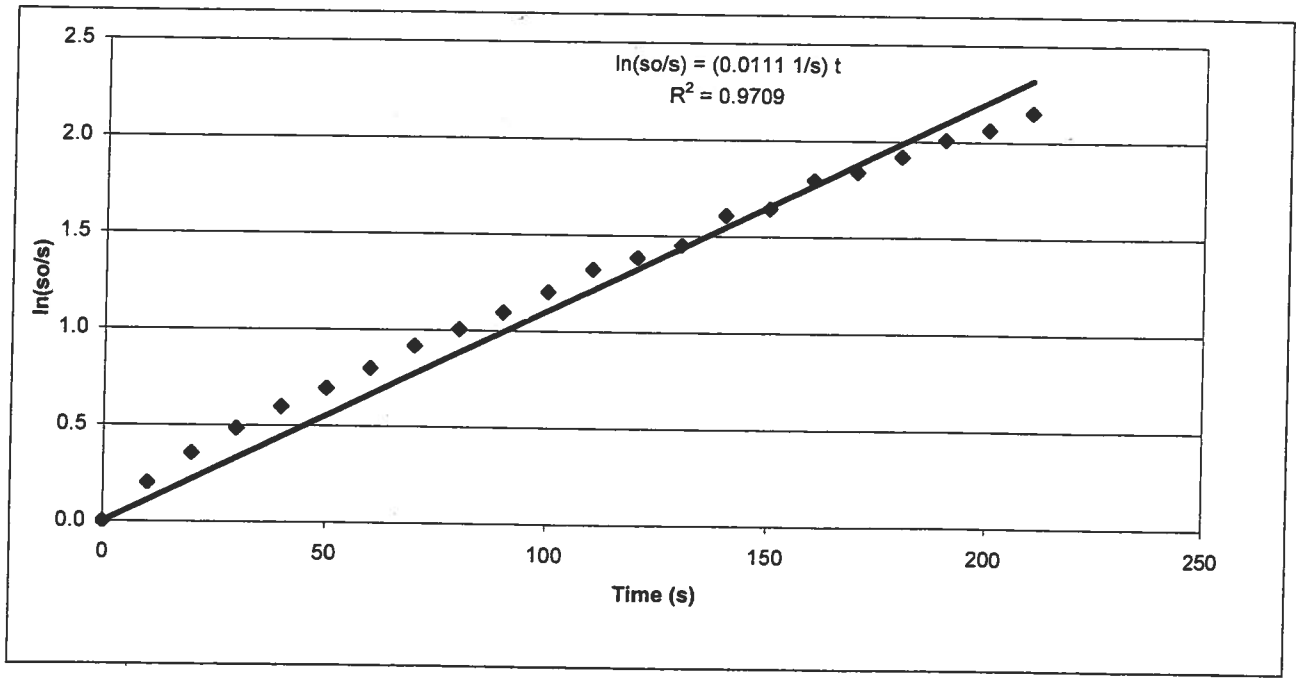
WATER-RESOURCES INVESTIGATIONS
REPORT 87-4000 PLATE 2

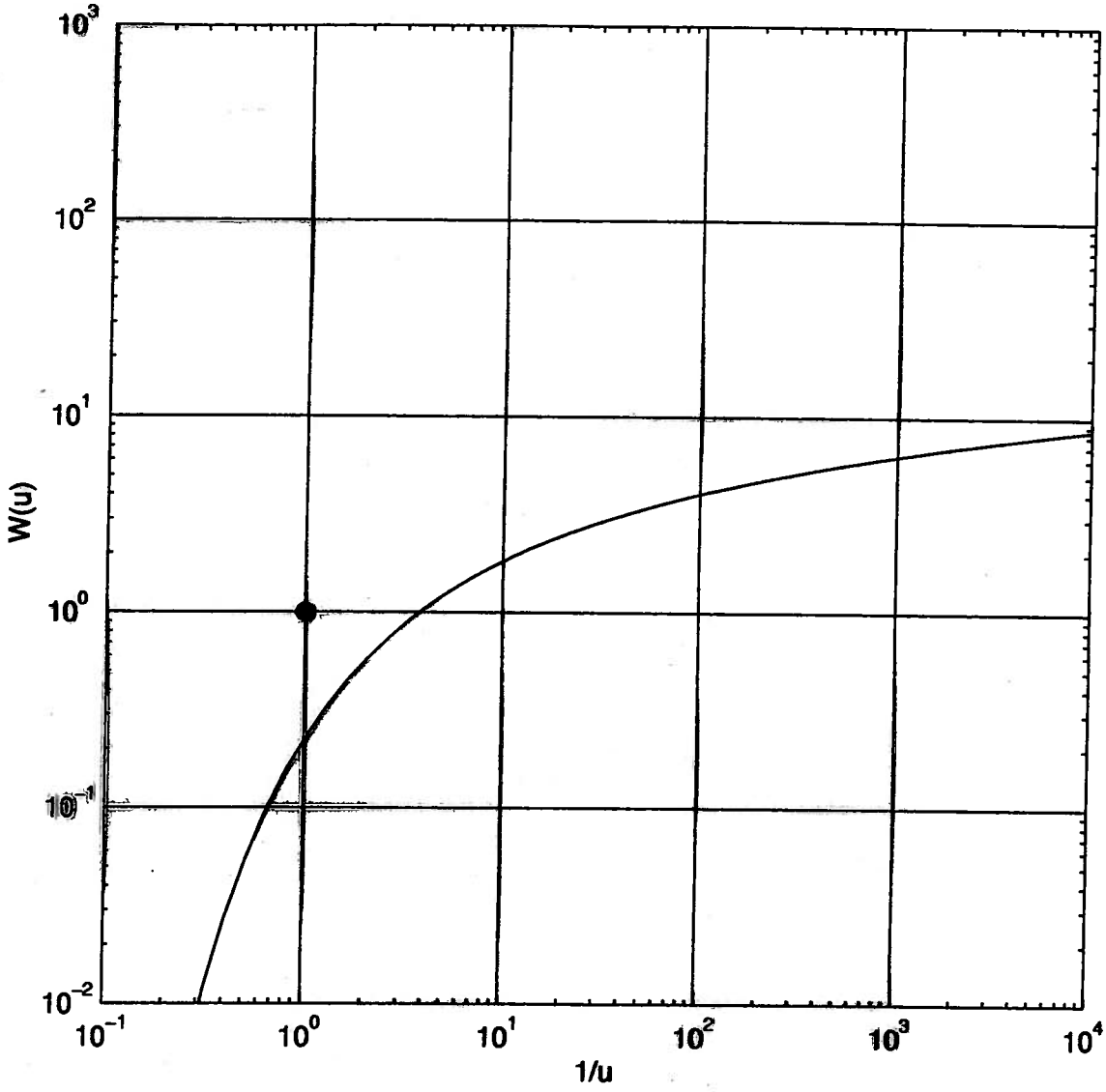


Altitude of the potentiometric surface of wells completed in deep stratified drift and bedrock, in the vicinity of wells G and H, December 4, 1985

R	3.8 cm
D	118 cm

Time (s)	Depth to Water (cm)	Drawdown (cm)	so/s	ln(so/s)
0	29.60	5.60	1.00	0.00
10	28.57	4.57	1.23	0.20
20	27.92	3.92	1.43	0.36
30	27.45	3.45	1.62	0.48
40	27.08	3.08	1.82	0.60
50	26.80	2.80	2.00	0.69
60	26.52	2.52	2.22	0.80
70	26.24	2.24	2.50	0.92
80	26.05	2.05	2.73	1.00
90	25.87	1.87	2.99	1.10
100	25.68	1.68	3.33	1.20
110	25.49	1.49	3.76	1.32
120	25.40	1.40	4.00	1.39
130	25.31	1.31	4.27	1.45
140	25.12	1.12	5.00	1.61
150	25.08	1.08	5.19	1.65
160	24.93	0.93	6.02	1.80
170	24.89	0.89	6.29	1.84
180	24.82	0.82	6.83	1.92
190	24.75	0.75	7.47	2.01
200	24.71	0.71	7.89	2.07
210	24.65	0.65	8.62	2.15

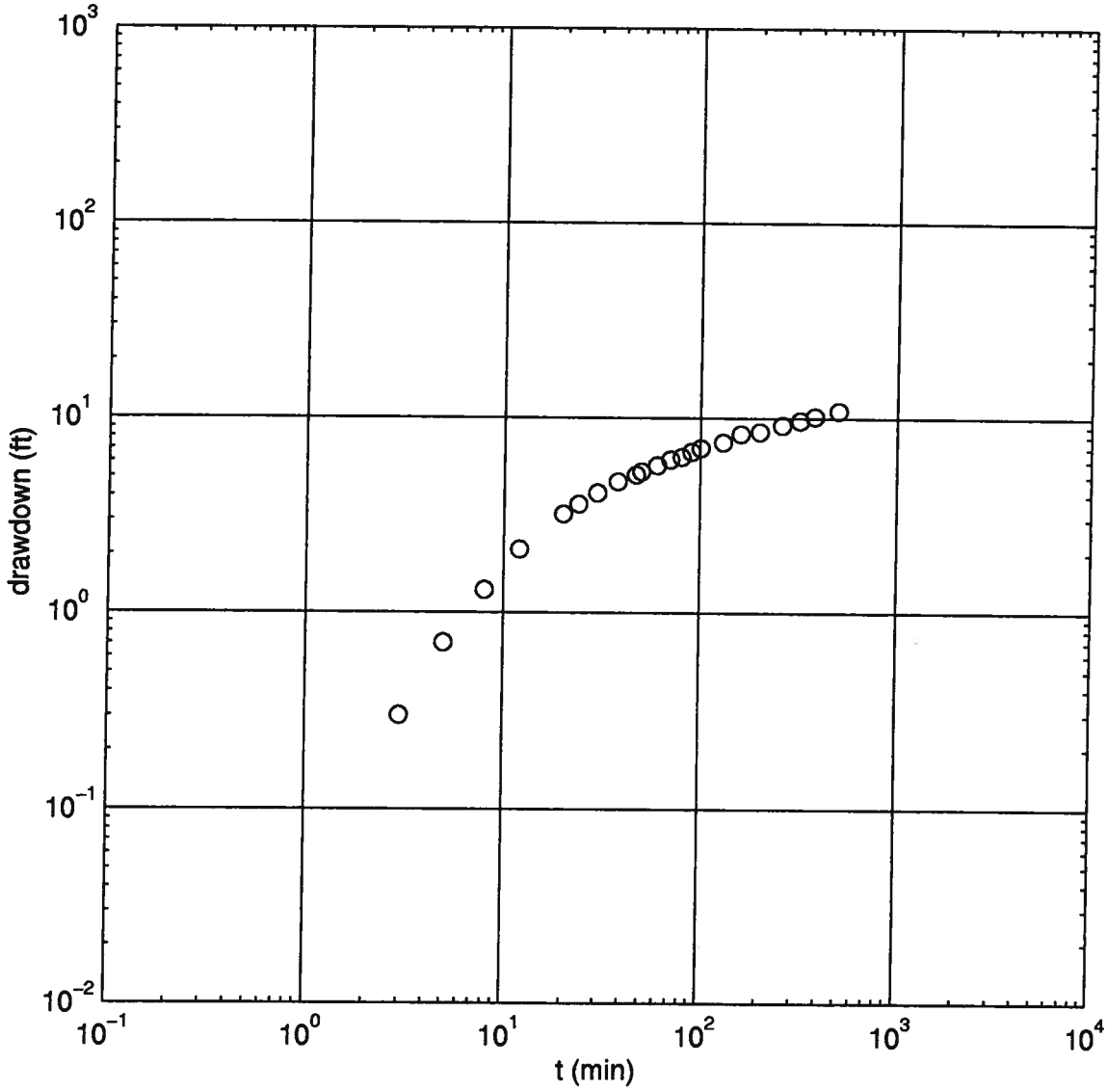


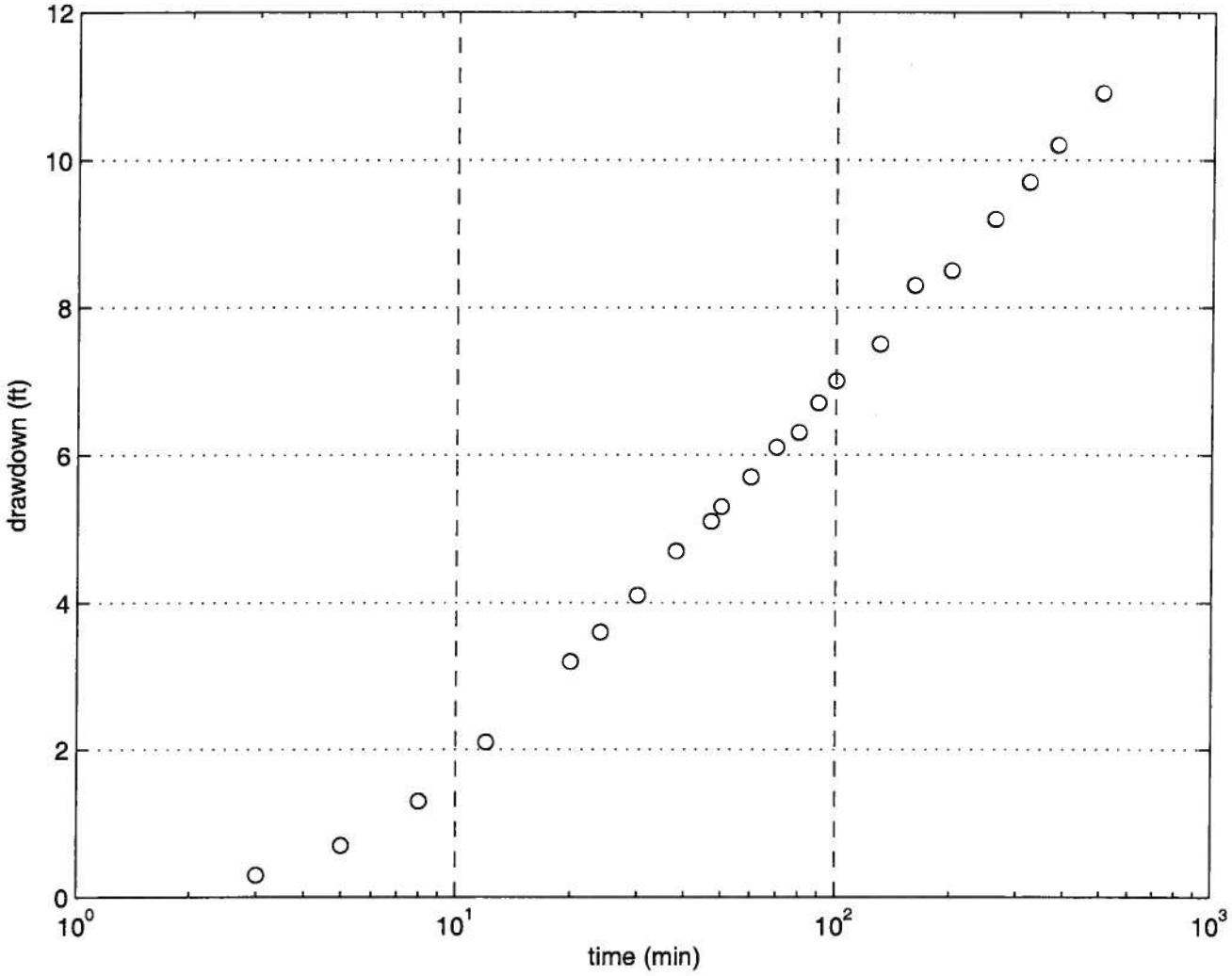

10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
W(u)
10^{-1}
10^0
10^1
10^2
10^3
10^4
1/u

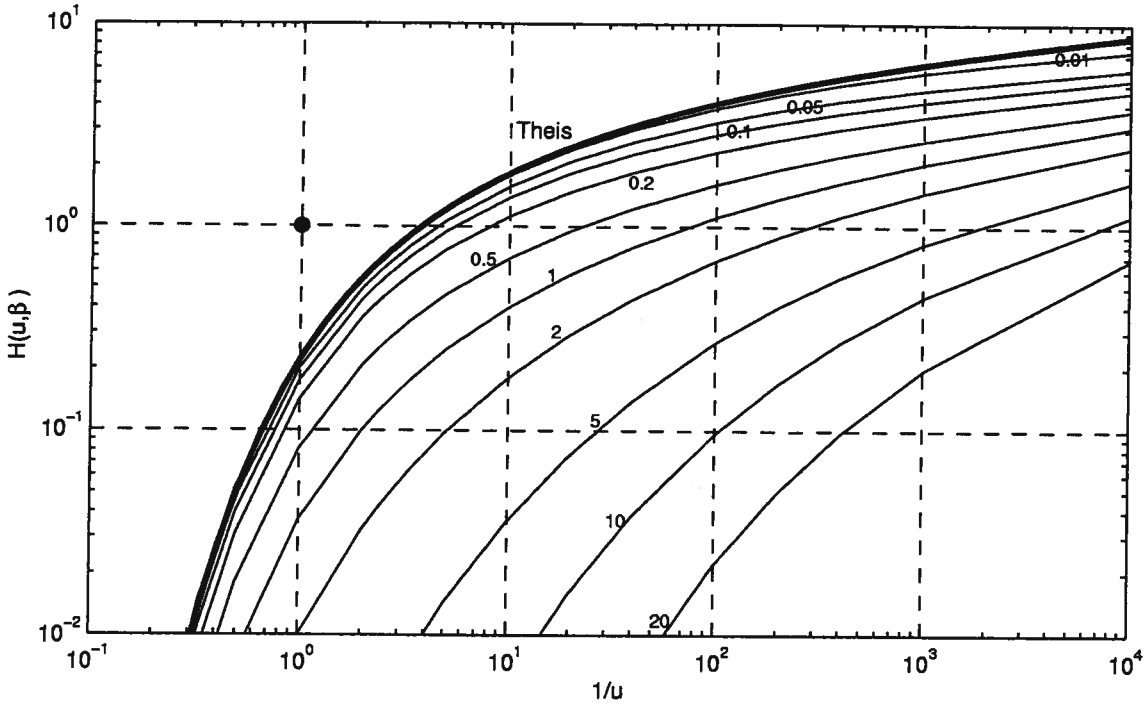
Drawdown data for example problem

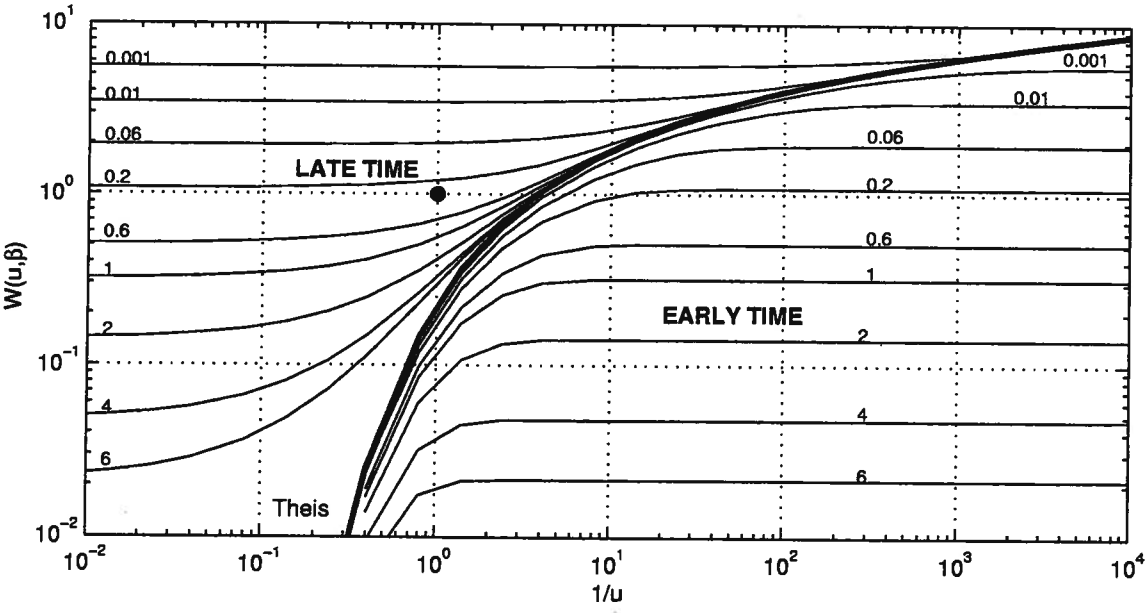
Time (min)	Drawdown (ft)
3	0.3
5	0.7
8	1.3
12	2.1
20	3.2
24	3.6
30	4.1
38	4.7
47	5.1
50	5.3
60	5.7
70	6.1
80	6.3
90	6.7
100	7.0
130	7.5
160	8.3
200	8.5
260	9.2
320	9.7
380	10.2
500	10.9

Example - Theis

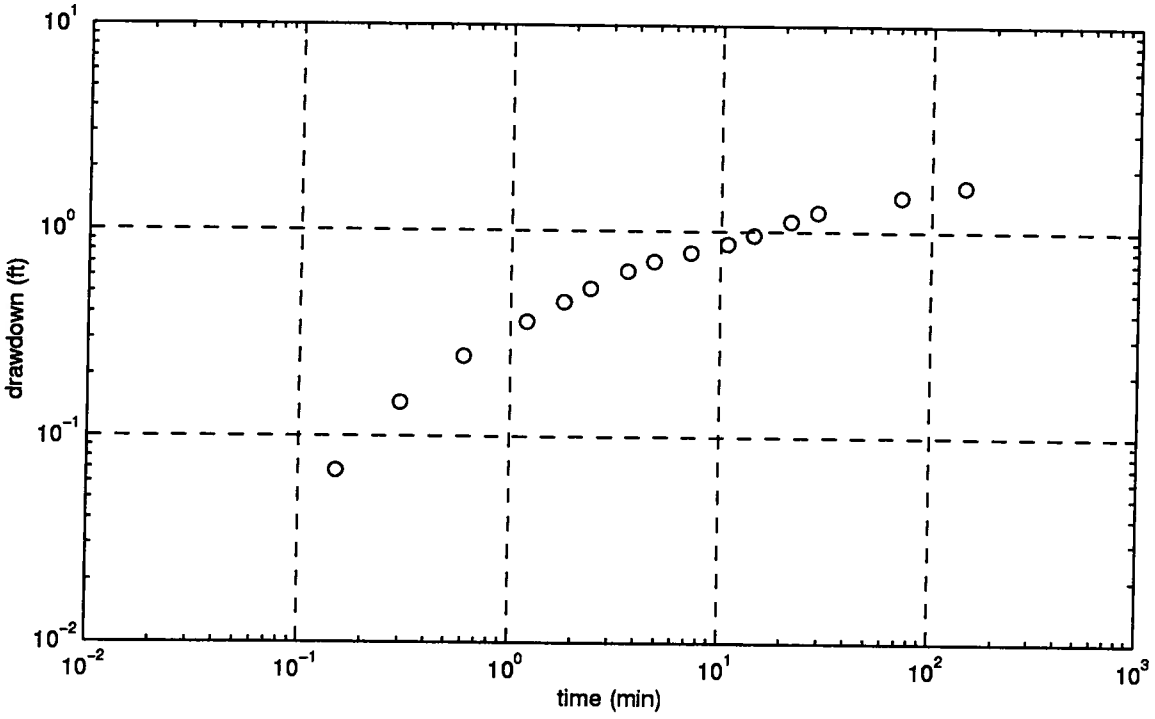



12
10
8
6
4
2
0
drawdown (ft)
10^0
10^1
10^2
10^3
time (min)

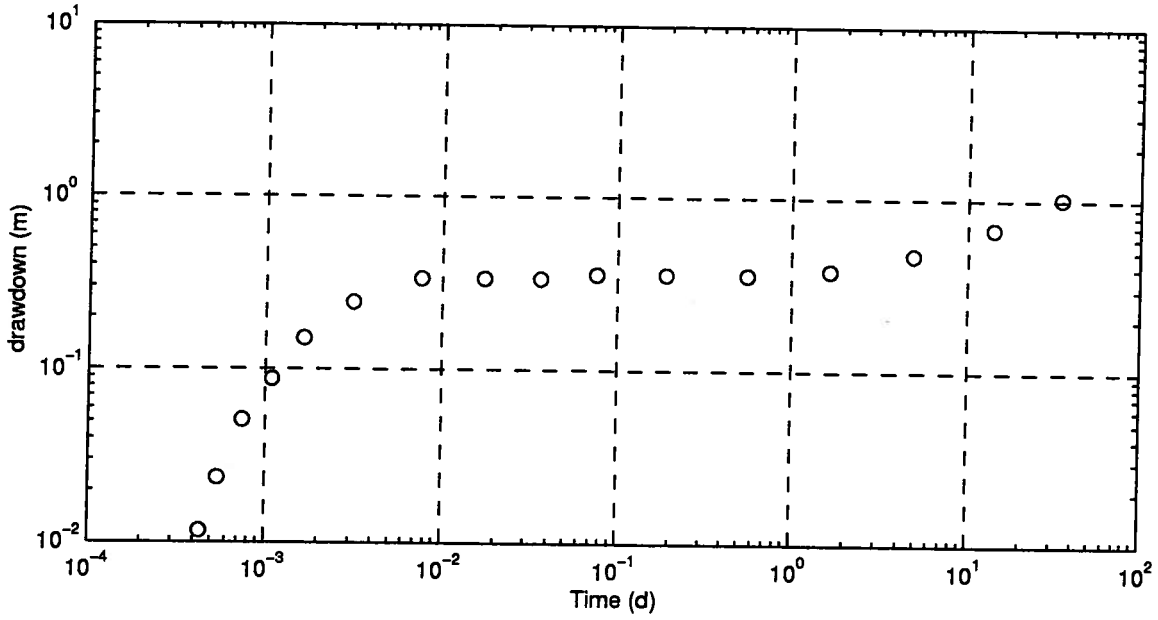

H(u,β)
1/u
Theis
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20

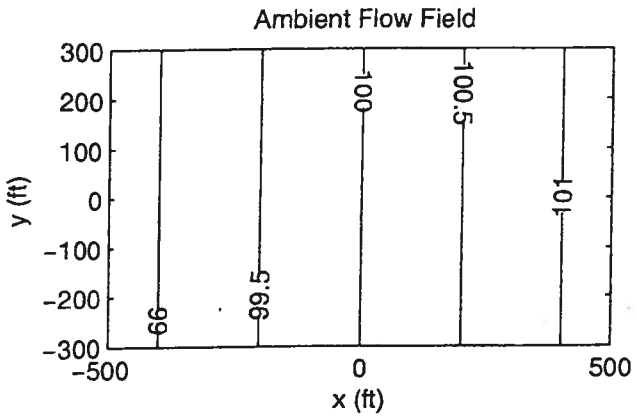

W(u,β)
1/u
LATE TIME
EARLY TIME
Theis
0.001
0.01
0.06
0.2
0.6
1
2
4
6

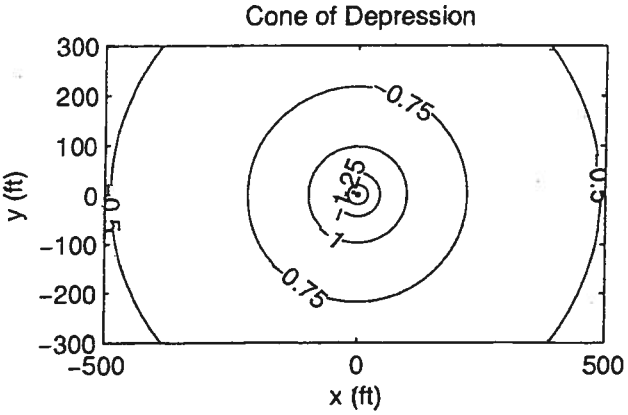
Example - Leaky Aquifer

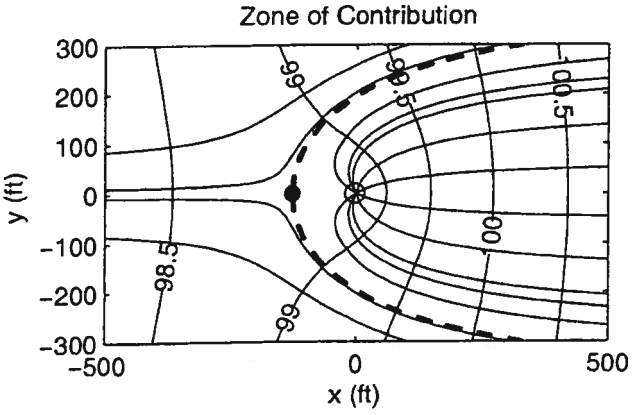


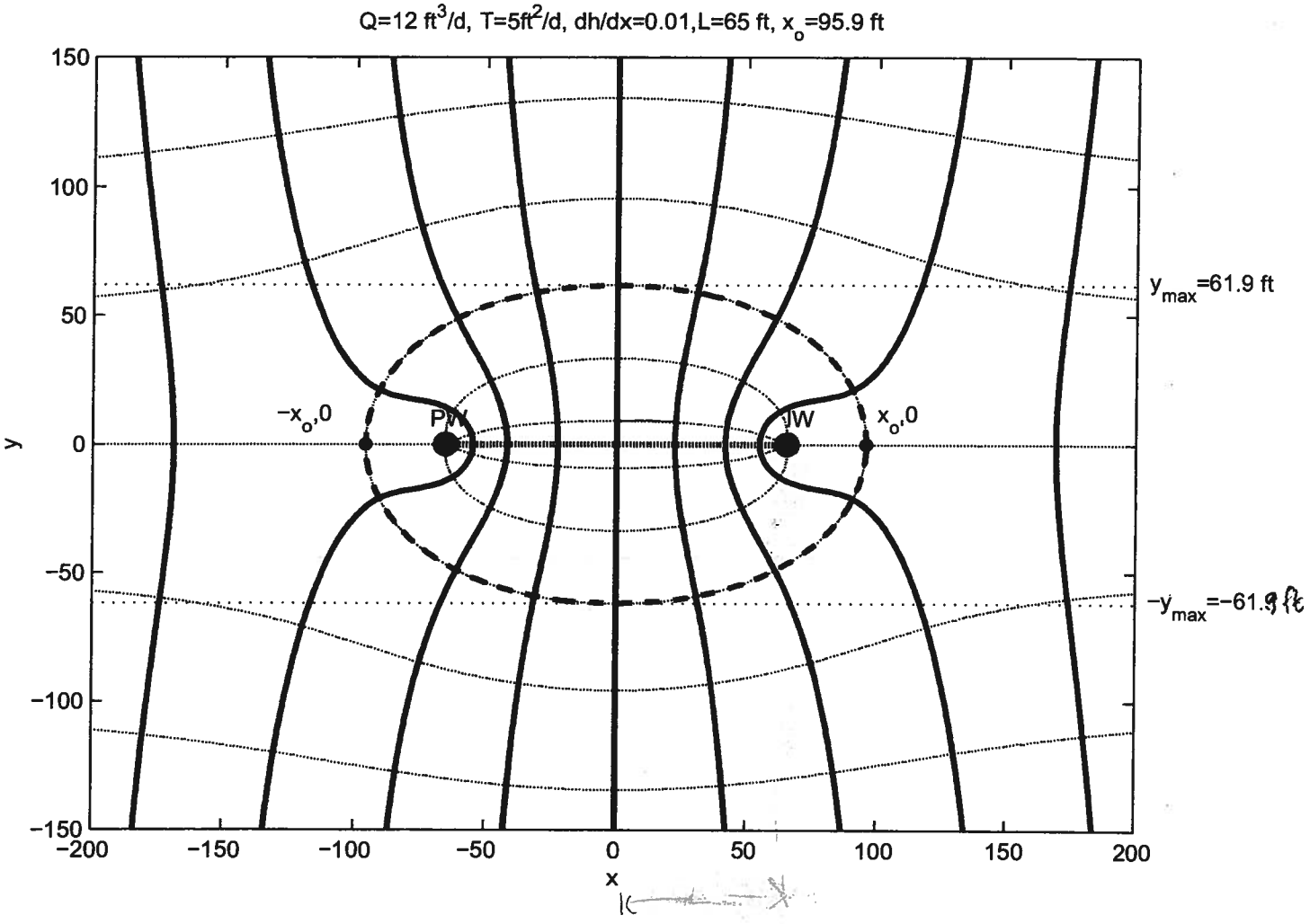
Example - Unconfined Aquifer

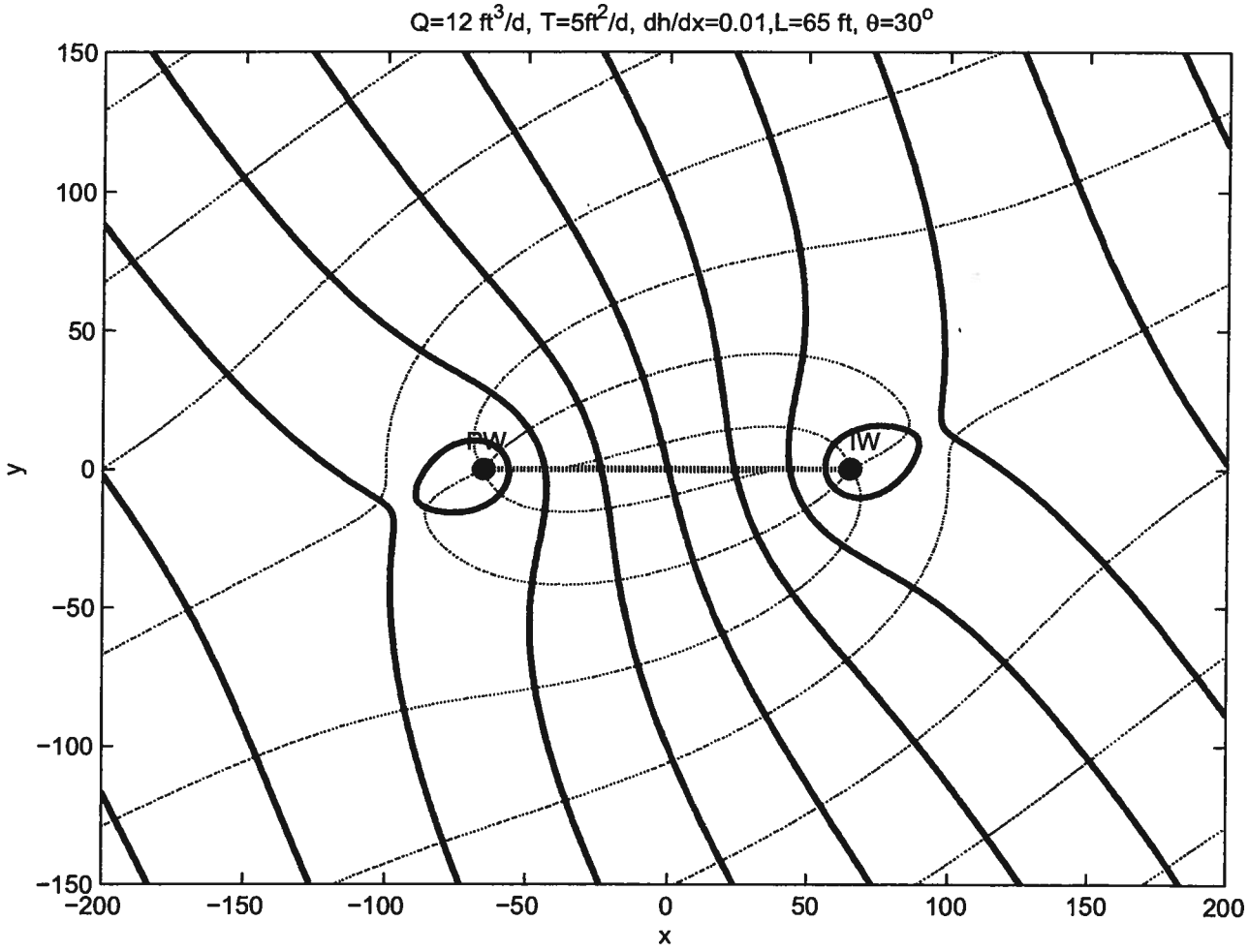



Ambient Flow Field
300
200
100
0
-100
-200
-300
y (ft)
-500
0
500
x (ft)
99
99.5
100
100.5
101


Cone of Depression
300
200
100
0
-100
-200
-300
y (ft)
-500
0
500
x (ft)
0.75
0.5
0.25
1
0.75
0.5


Zone of Contribution
300
200
100
0
-100
-200
-300
y (ft)
-500
0
500
x (ft)
99
99.5
100
100.5
98.5
99
100
98.5
99


Q=12 ft3/d, T=5ft2/d, dh/dx=0.01,L=65 ft, xo=95.9 ft
150
100
50
0
−50
−100
−150
−200
−150
−100
−50
0
50
100
150
200
y
x
−xo,0
PW
IW
xo,0
ymax=61.9 ft
−ymax=−61.9 ft


Q=12 ft3/d, T=5ft2/d, dh/dx=0.01,L=65 ft, θ=30o
PW
IW
150
100
50
0
−50
−100
−150
−200
−150
−100
−50
0
50
100
150
200
x
y

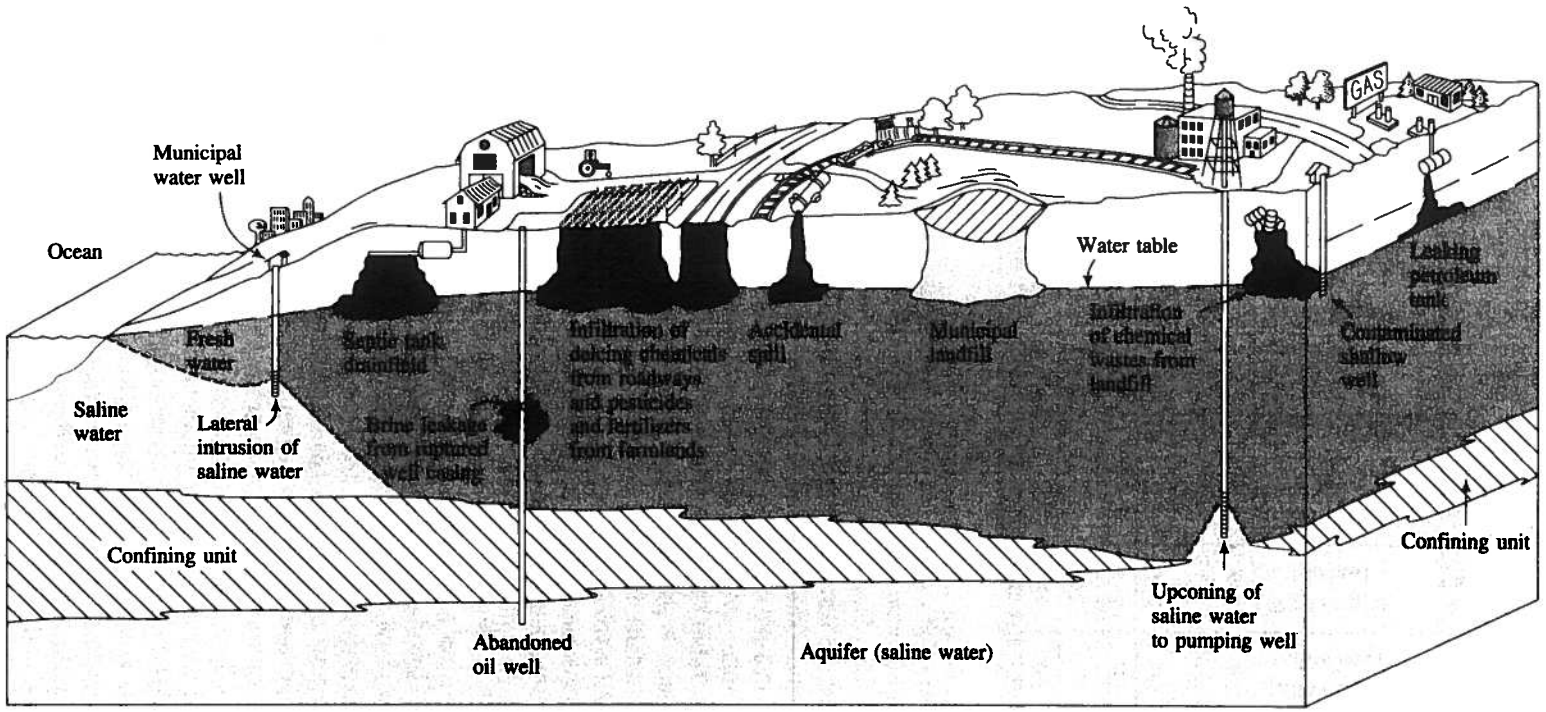
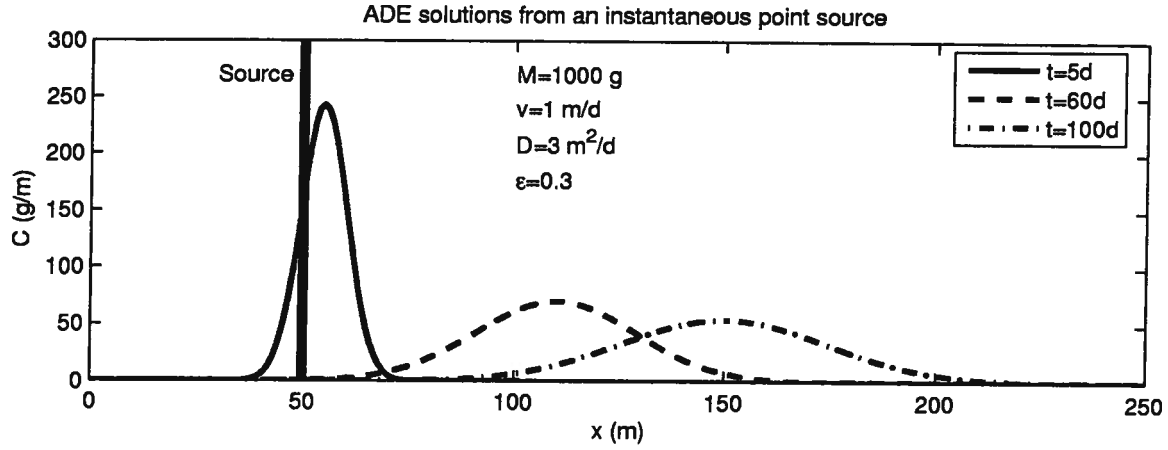
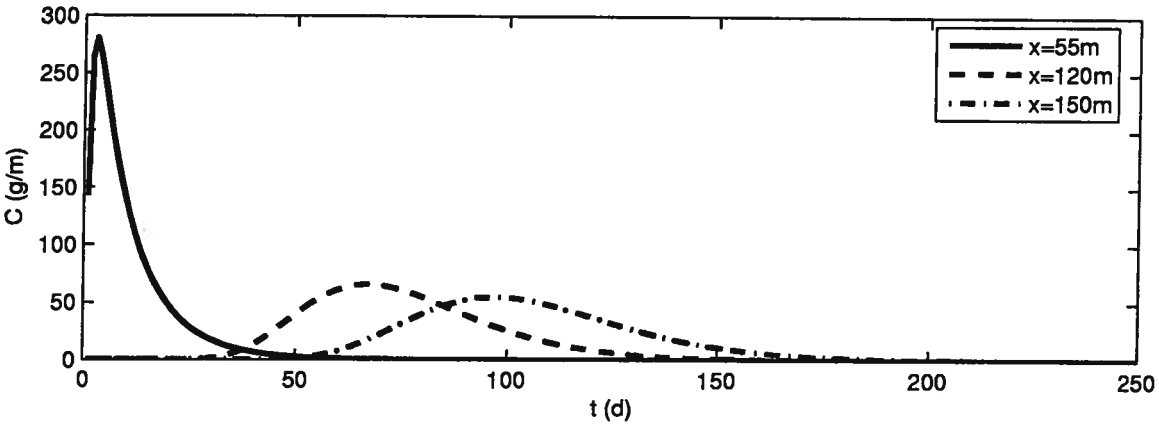
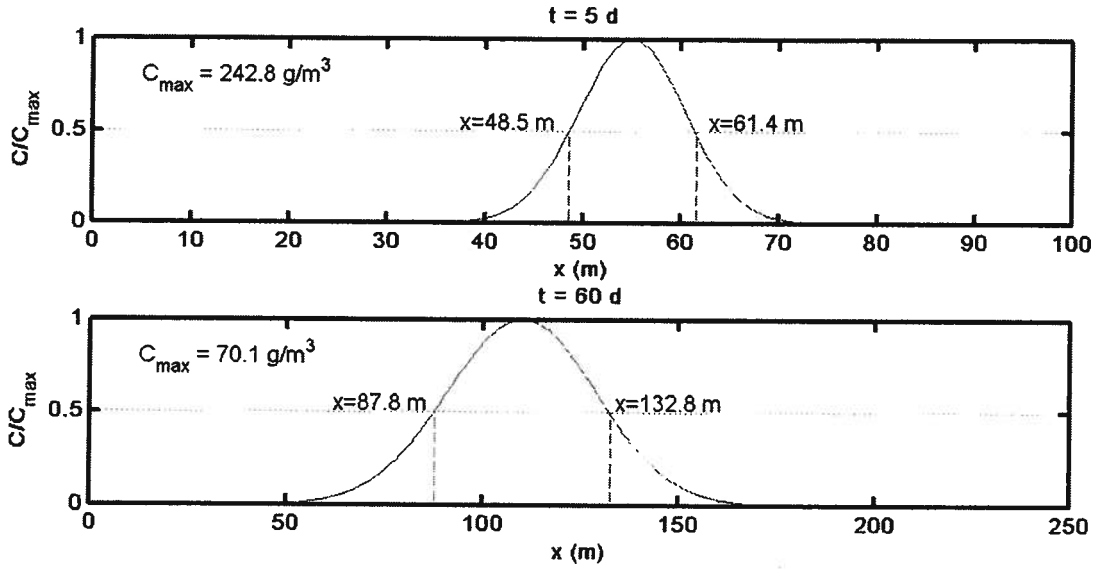
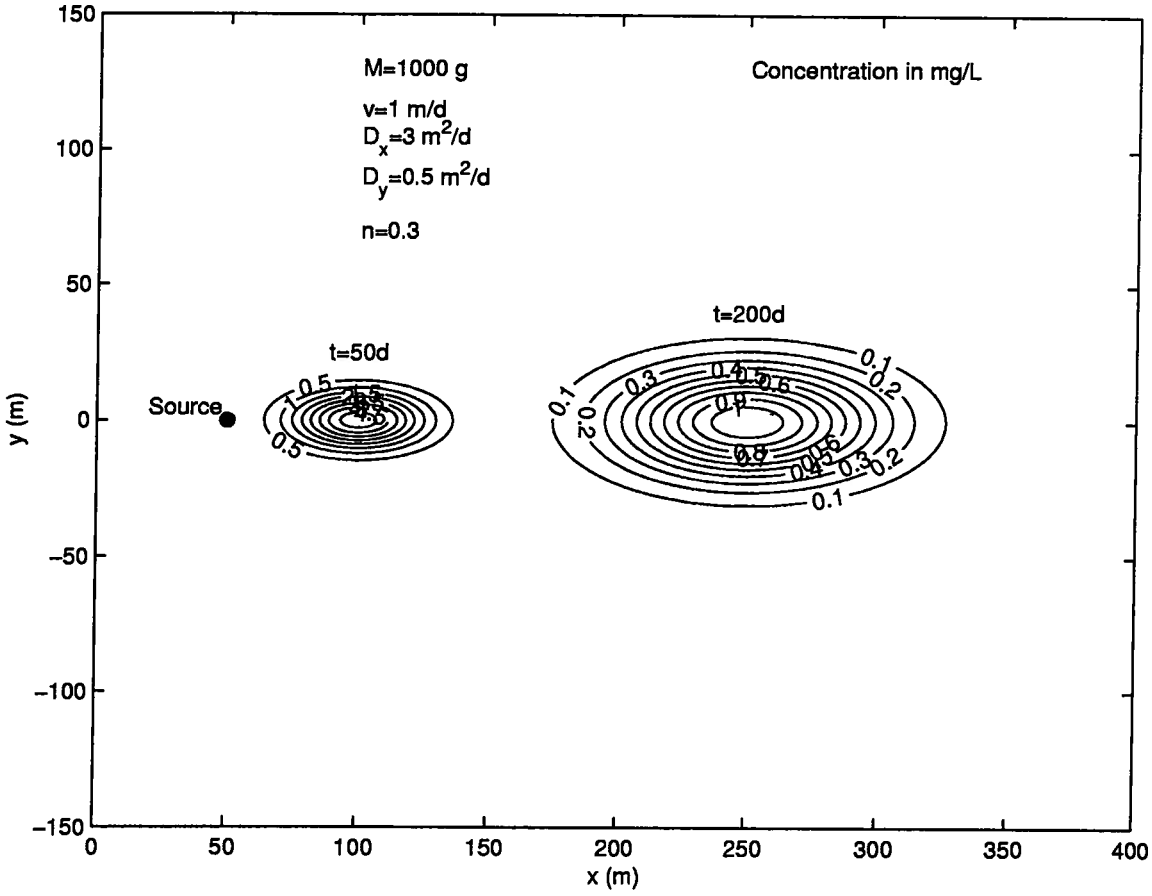


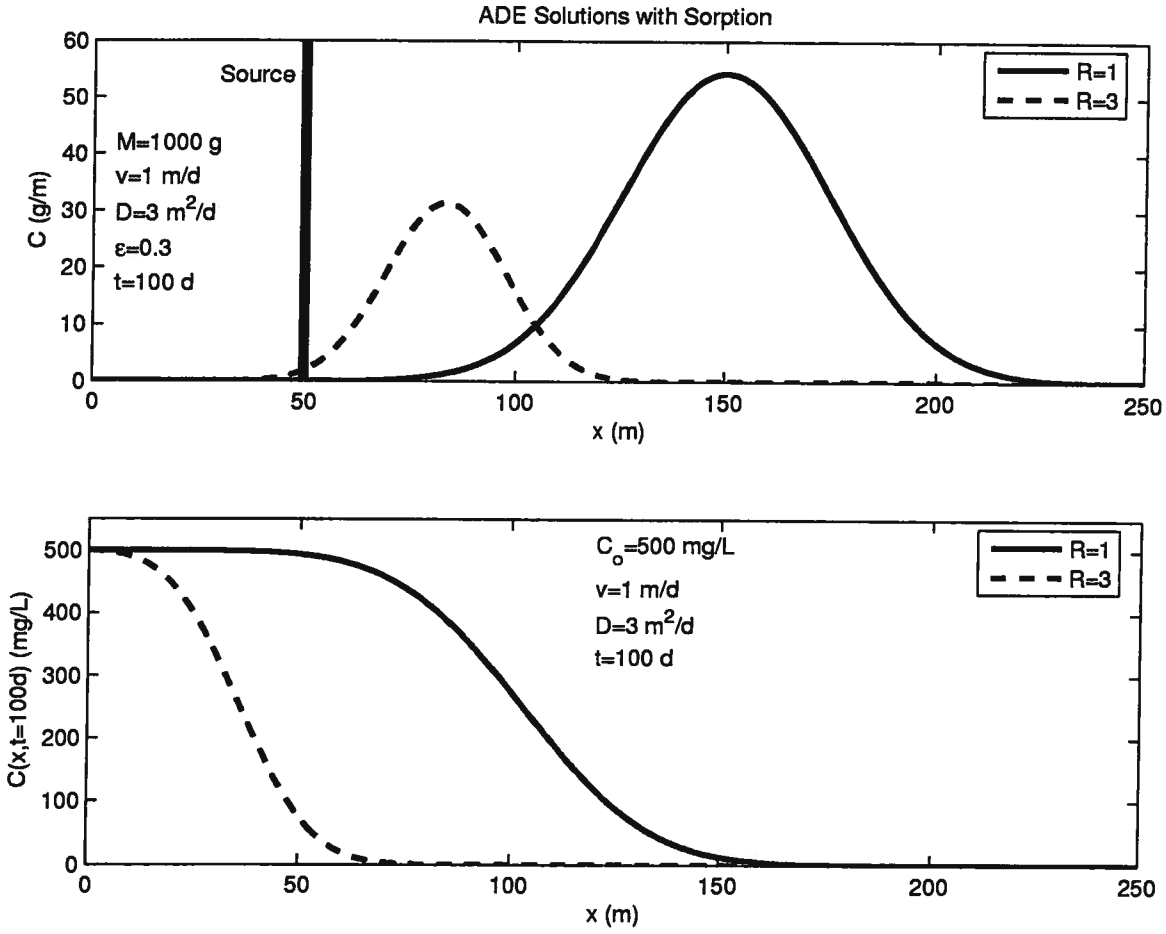
FIGURE 1.1 Mechanisms of ground-water contamination.


ADE solutions from an instantaneous point source
Source
M=1000 g
v=1 m/d
D=3 m²/d
ε=0.3
t=5d
t=60d
t=100d
C (g/m)
x (m)
0
50
100
150
200
250
300


x=55m
x=120m
x=150m
C (g/m)
t (d)
0
50
100
150
200
250
300


t = 5 d
C/C_max
C_max = 242.8 g/m^3
x=48.5 m
x=61.4 m
x (m)
t = 60 d
C/C_max
C_max = 70.1 g/m^3
x=87.8 m
x=132.8 m
x (m)


M=1000 g
v=1 m/d
D_x=3 m^2/d
D_y=0.5 m^2/d
n=0.3
Concentration in mg/L
t=50d
t=200d
Source
y (m)
x (m)
150
100
50
0
−50
−100
−150
0
50
100
150
200
250
300
350
400


ADE Solutions with Sorption
Source
M=1000 g
v=1 m/d
D=3 m²/d
ε=0.3
t=100 d
R=1
R=3
C (g/m)
x (m)
C_o=500 mg/L
v=1 m/d
D=3 m²/d
t=100 d
C(x,t=100d) (mg/L)

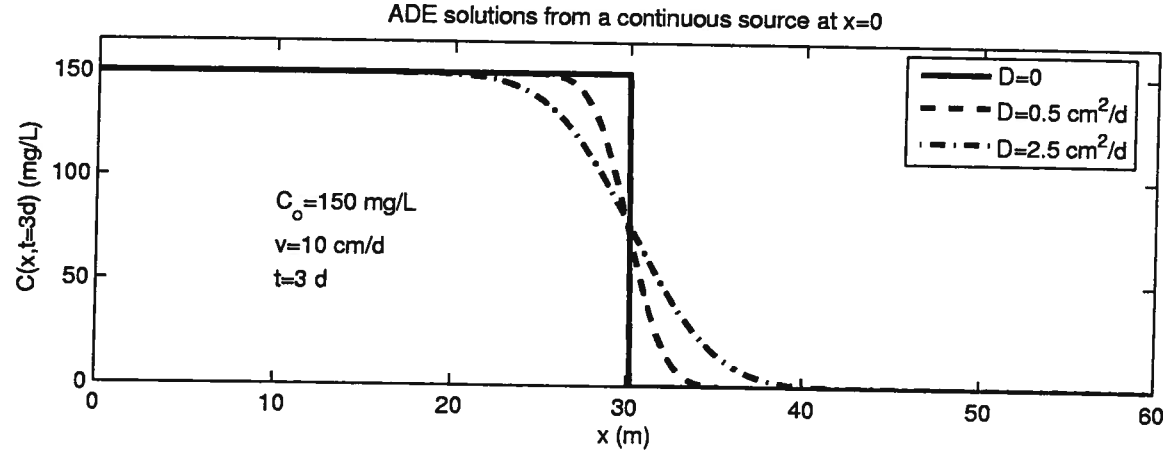
Appendix V Complementary Error Function (erfc)

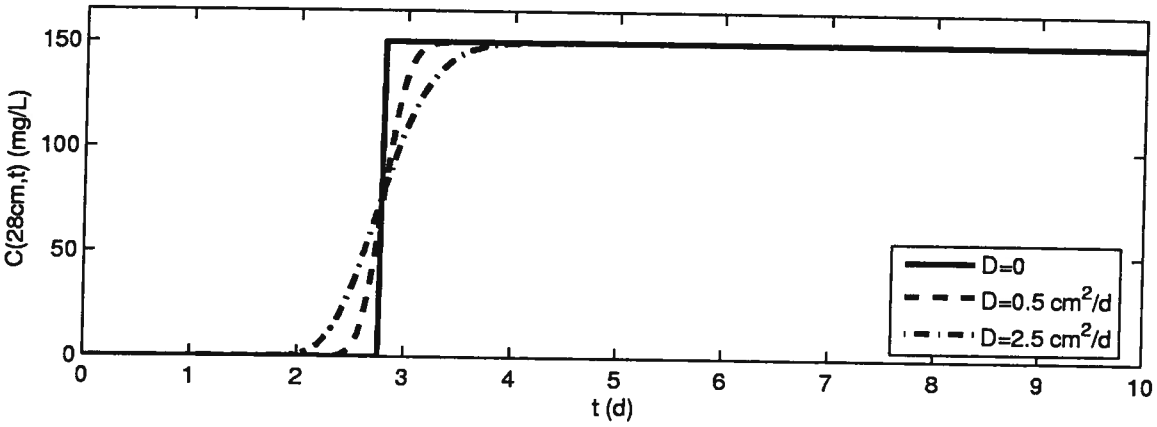
$$\operatorname{erf}(\beta) = \frac{2}{\sqrt{\mu}} \int_0^{\beta} e^{-\epsilon^2}\, d\epsilon$$

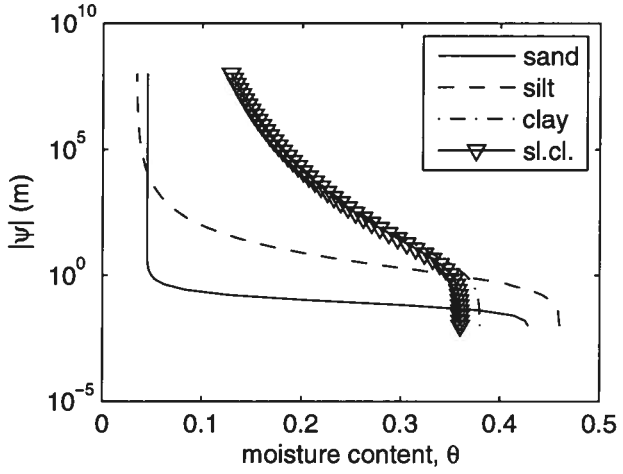
$$\operatorname{erf}(-\beta) = -\operatorname{erf}\beta$$

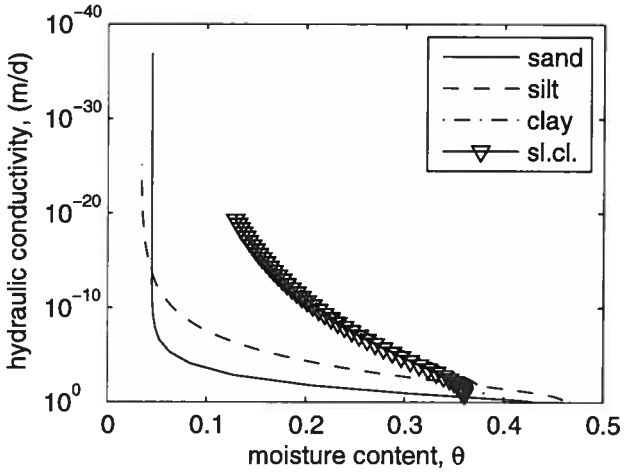
$$\operatorname{erfc}(\beta) = 1 - \operatorname{erf}(\beta)$$

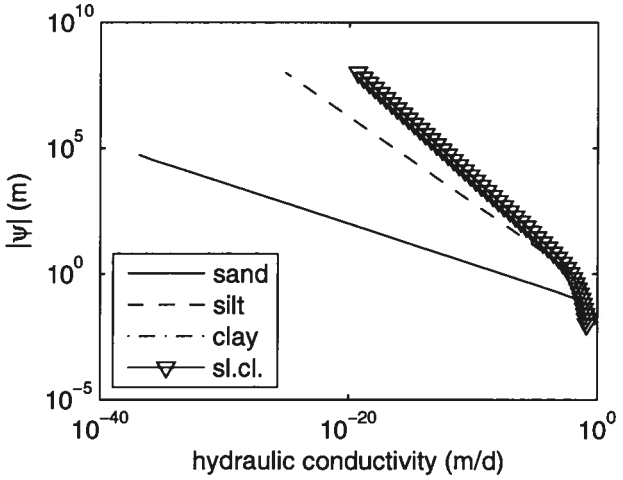
β	erf (β)	erfc (β)
0	0	1.0
0.05	0.056372	0.943628
0.1	0.112463	0.887537
0.15	0.167996	0.832004
0.2	0.222703	0.777297
0.25	0.276326	0.723674
0.3	0.328627	0.671373
0.35	0.379382	0.620618
0.4	0.428392	0.571608
0.45	0.475482	0.524518
0.5	0.520500	0.479500
0.55	0.563323	0.436677
0.6	0.603856	0.396144
0.65	0.642029	0.357971
0.7	0.677801	0.322199
0.75	0.711156	0.288844
0.8	0.742101	0.257899
0.85	0.770668	0.229332
0.9	0.796908	0.203092
0.95	0.820891	0.179109
1.0	0.842701	0.157299
1.1	0.880205	0.119795
1.2	0.910314	0.089686
1.3	0.934008	0.065992
1.4	0.952285	0.047715
1.5	0.966105	0.033895
1.6	0.976348	0.023652
1.7	0.983790	0.016210
1.8	0.989091	0.010909
1.9	0.992790	0.007210
2.0	0.995322	0.004678
2.1	0.997021	0.002979
2.2	0.998137	0.001863
2.3	0.998857	0.001143
2.4	0.999311	0.000689
2.5	0.999593	0.000407
2.6	0.999764	0.000236
2.7	0.999866	0.000134
2.8	0.999925	0.000075
2.9	0.999959	0.000041
3.0	0.999978	0.000022


ADE solutions from a continuous source at x=0
C(x,t=3d) (mg/L)
150
100
50
0
0
10
20
30
40
50
60
x (m)
C_o=150 mg/L
v=10 cm/d
t=3 d
D=0
D=0.5 cm²/d
D=2.5 cm²/d

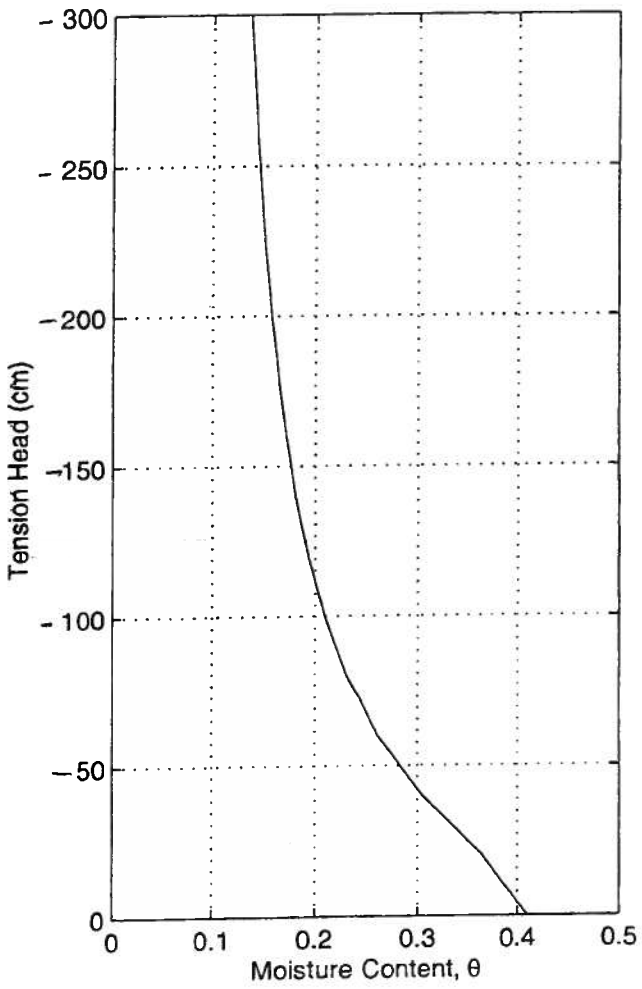

C(28cm,t) (mg/L)
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
t (d)
D=0
D=0.5 cm²/d
D=2.5 cm²/d

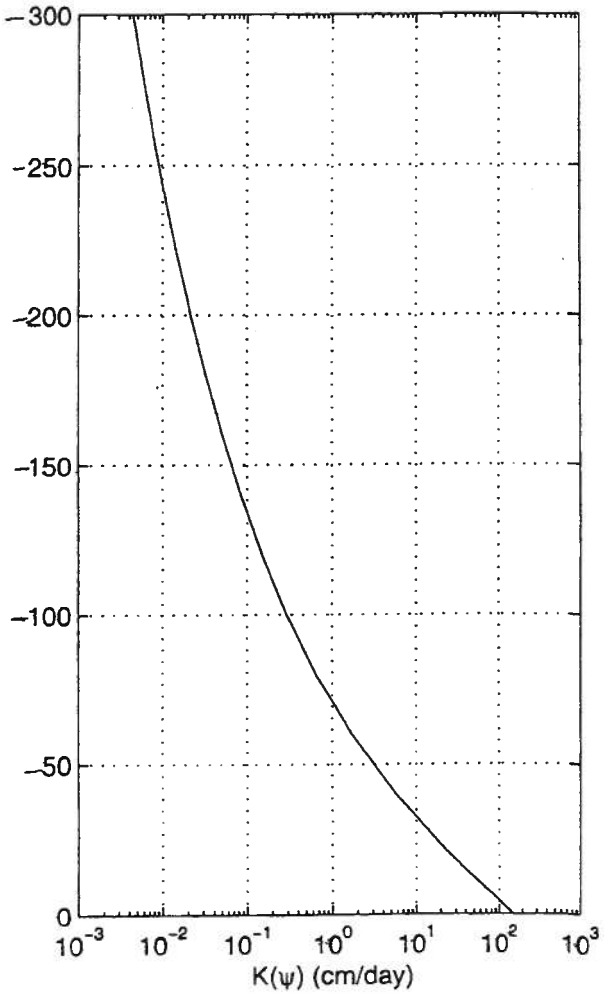




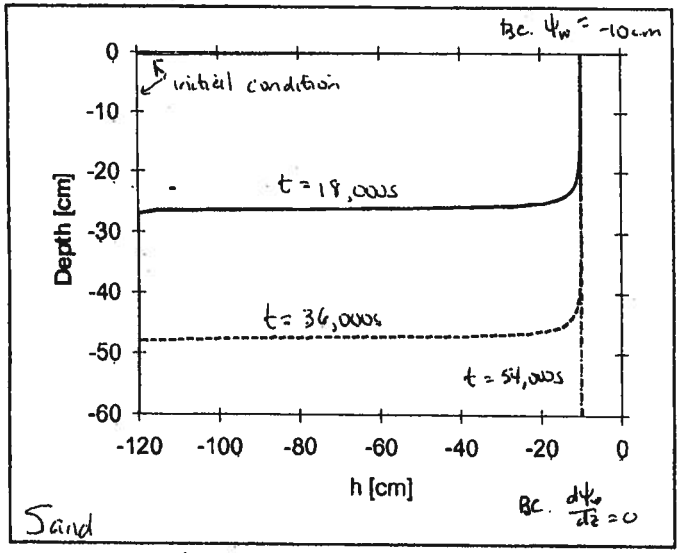


Soil	n	K (m/d)	θ_r	α (1/m)	β
Sand	0.43	7.1	0.045	14.5	2.68
Silt	0.46	0.06	0.034	1.6	1.37
Clay	0.38	0.048	0.068	0.8	1.09
Sl.cl.	0.36	0.0048	0.07	0.5	1.09

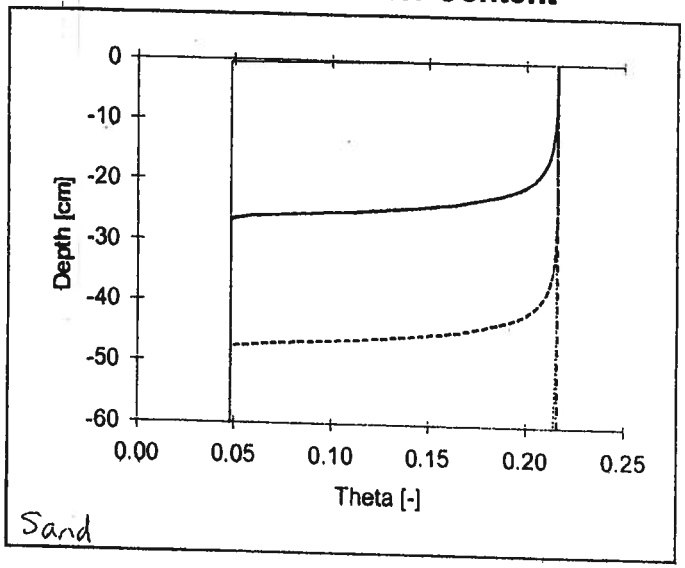

Tension Head (cm)
-300
-250
-200
-150
-100
-50
0
0
0.1
0.2
0.3
0.4
0.5
Moisture Content, θ


-300
-250
-200
-150
-100
-50
0
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
K(ψ) (cm/day)

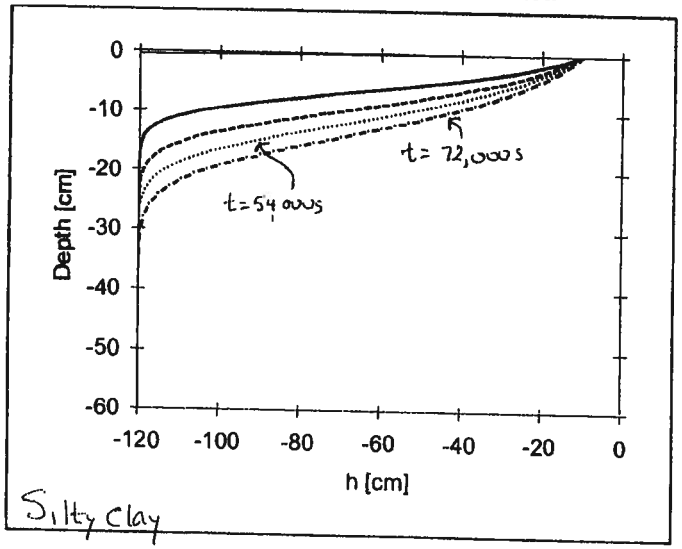
Profile Information: Pressure Head



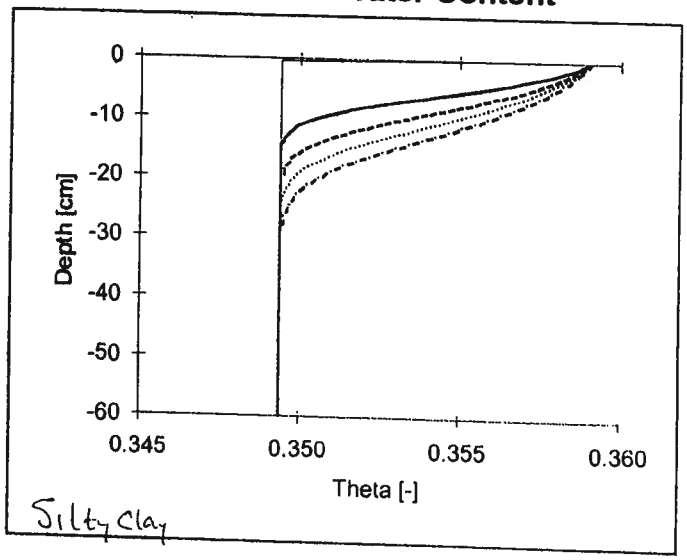
Profile Information: Water Content



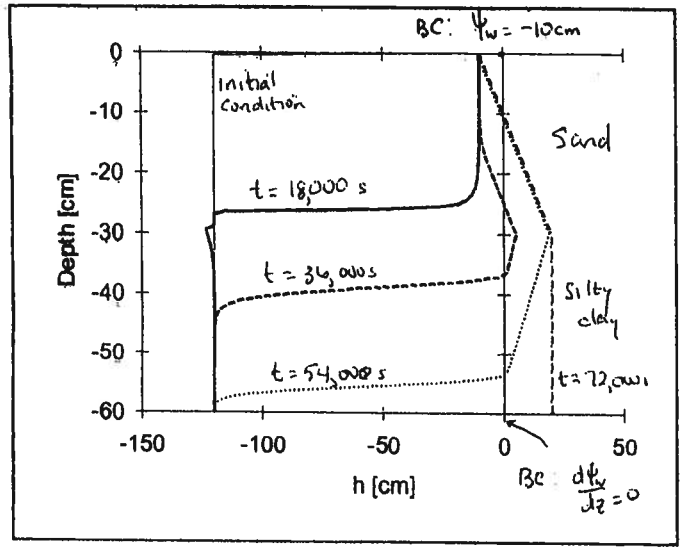
Profile Information: Pressure Head



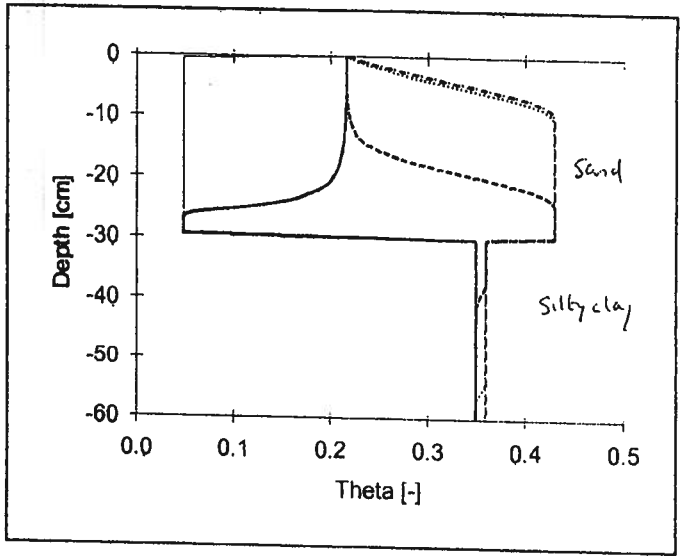
Profile Information: Water Content



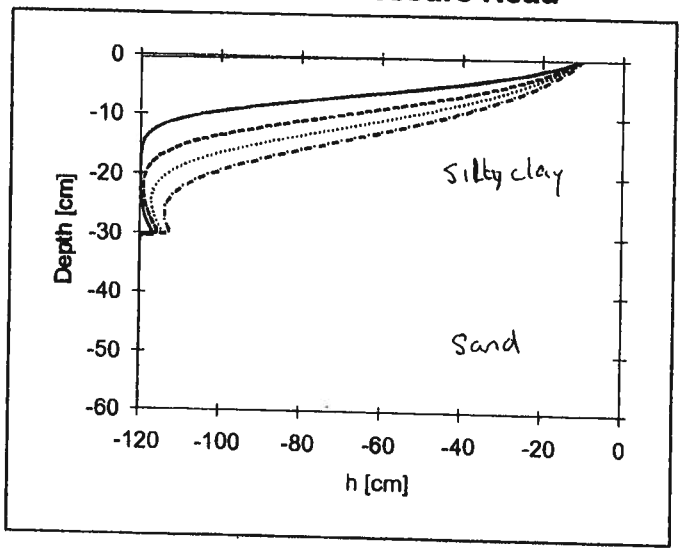
Profile Information: Pressure Head



Profile Information: Water Content



Profile Information: Pressure Head



Profile Information: Water Content