APPENDIX F

GRAIN SIZE ANALYSIS AND IN-SITU PERMEABILITY TESTING DATA

This appendix contains the results of grain size analysis performed on selected samples obtained from NUS/FIT borings at the Wells G & H Site. Data from grain size analysis is used to calculate permeabilities of overburden materials in the study area. Also included in this appendix are data from in-situ permeability testing conducted during the drilling of selected NUS/FIT monitoring wells. This type of testing allows a direct measurement of permeability of a selected interval in the borehole. Permeability testing was conducted by utilizing falling-head and using-head methodologies.

Sixteen in-situ permeability tests were conducted in seven boreholes during the installation of monitoring wells on site. Two methods were used (for comparison) to determine values for permeability: the Basic Time Lag method and the Falling Head method. Review of the results from both methods indicated a very good correlation.

The Basic Time Lag method involves a semi-logarithmic plot of the field data. The logarithm of the Head Ratio (H/H_o) is plotted against the corresponding values of time (t), where H is the water level at t and H_o is the initial water level at the start of the test ($t = 0$). A best fitting straight line is drawn through the experimental points. The value of t on this straight line corresponding to $H/H_o = 0.37$ is the required value of he Basic Time Lag (T) (U.S. Bureau of Reclamation, 1975). The calculated value for the Basic Time Lag is used in the following formula to calculate the permeability.

$$K = \frac{\pi \ d}{11T}$$

Where:

K = permeability (cm/sec)
d = diameter of the standpipe (cm)
T = Basic Time Lag (sec)

Determining permeability using the Falling Head method involves the following formula (Lambe and Whitman, 1969):

$$K = \frac{\pi \ d}{11 \ (t_2 - t_1)} \qquad \text{Ln } H_1/H_2$$

Where:

K = permeability (cm/sec)
d = diameter of the standpipe (cm)
t_1 = time at beginning of test (sec)
t_2 = time at end of test (sec)
H_1 = Water level at $t = t_1$
H_2 = water level at $t = t_2$

The range of permeabilities coincide with those permeabilities determined for similar unconsolidated deposits as outlined by Freeze and Cherry, 1979 (page 29). The permeabilities calculated from grain size data correlates fairly well to each geologic unit tested, although the permeability estimates based on grain size analysis were typically lower than the corresponding in-situ test results.

Permeability Calculations

Basic Time Lag Method

$K = \frac{\pi D}{11 T}$

K = mean coeff. perm. (cm/s)

D = diameter, intake sample (cm)

T = Basic Time Lag (sec.)

Falling Head Method

$K = \frac{\pi D}{11(t_2 - t_1)} \ln \frac{H_1}{H_2}$

K = mean coeff. perm. (cm/s)

D = diameter, intake sample (cm)

t = time (sec)

H_1 = head for $t = t_1$

H_2 = head for $t = t_2$

Well No. S-64 (9-11') Brown silty sand, little clay.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ D = 7.62 cm, T = 1530 sec

$K = \frac{\pi\ 7.62}{11\ (1530)}$

$K = 1.42 \times 10^{-3}$ cm/sec

Falling Head

$K = \frac{\pi D}{11(t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11\ (2700)} \ln \frac{243.8}{45.7}$

$K = 1.35 \times 10^{-3}$ cm/sec

D = 7.62 cm
t_2 = 2700 sec
t_1 = 0
H_1 = 243.8 cm
H_2 = 45.7 cm

Well No. S-64 (19-21') Dark brown medium-coarse sand, some fine gravel.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ D = 7.62 cm, T = 22320 sec

$K = \frac{\pi\ (7.62)}{11\ (22320)}$

$K = 9.75 \times 10^{-4}$ cm/sec

Falling Head

$K = \frac{\pi D}{11\ (t_2 - t_1)} \ln \frac{H_1}{H_2}$

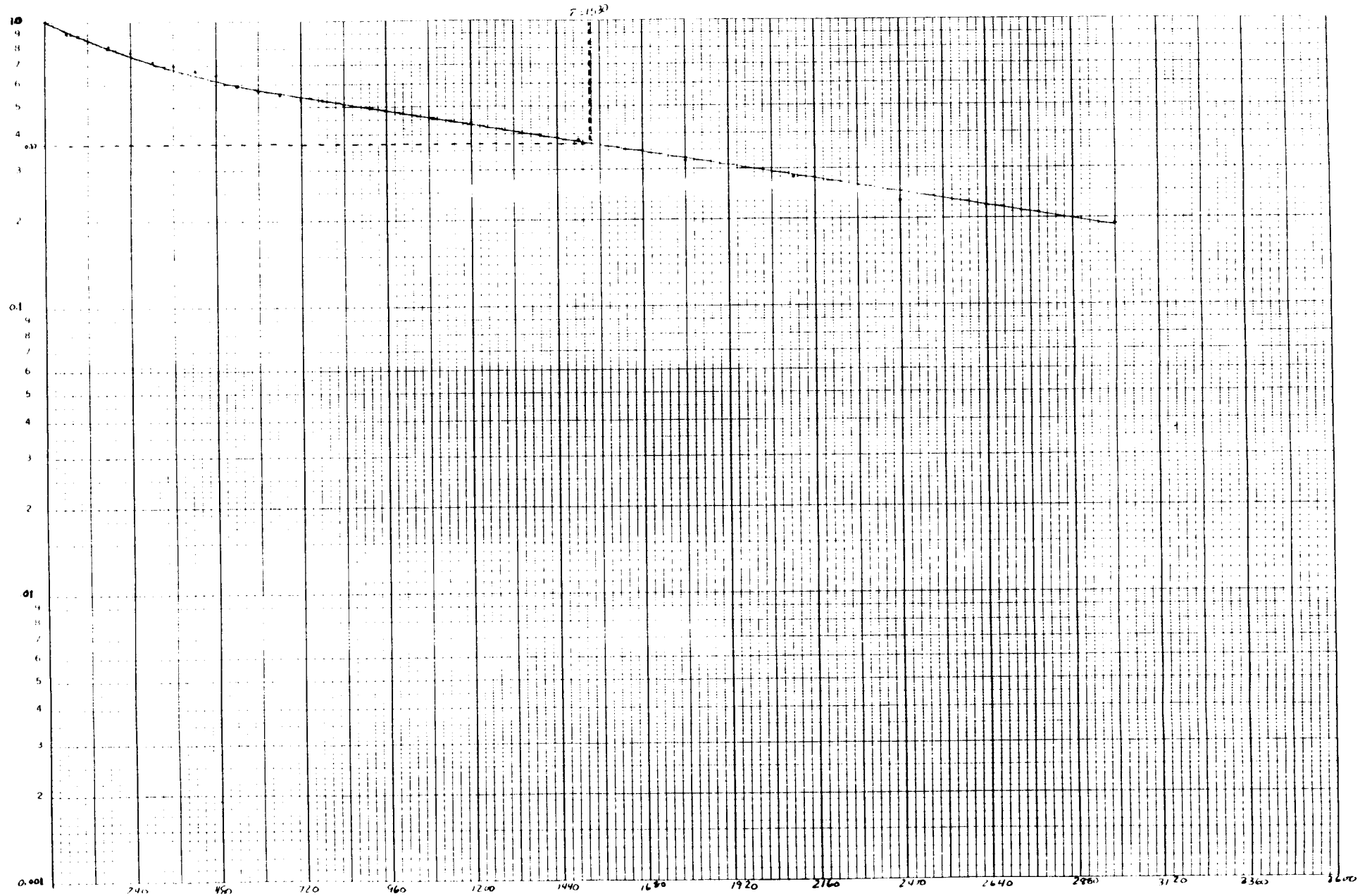
$K = \frac{\pi\ (7.62)}{11\ (2400)} \ln \frac{228.6}{207.0}$

$K = 8.9 \times 10^{-5}$ cm/sec

D = 7.62 cm
t_2 = 2400 sec
t_1 = 0
H_1 = 228.6 cm
H_2 = 207.0 cm

Well S-64 (9-11')
GW level from ground surface = 4.0'
Casing stick up from ground level = 4.0'
Depth of borehole below ground level = 11.0'
Casing diameter = 3.0"
H_o = 96.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	96.0	1.00	720	50.55	0.53
30	91.0	0.95	780	50.50	0.53
60	87.45	0.91	840	49.00	0.51
90	85.12	0.89	900	48.00	0.50
120	82.20	0.86	1200	42.30	0.44
150	80.75	0.84	1500	36.30	0.38
180	78.40	0.82	1800	30.50	0.32
210	75.80	0.80	2100	26.25	0.27
240	74.50	0.78	2400	22.00	0.23
270	72.88	0.76	2700	18.00	0.19
300	69.50	0.72			
360	67.40	0.70			
420	64.00	0.67			
480	62.75	0.65			
540	56.88	0.59			
600	54.50	0.57			
660	53.00	0.55			



DRAWDOWN CURVE

H/Ho vs TIME

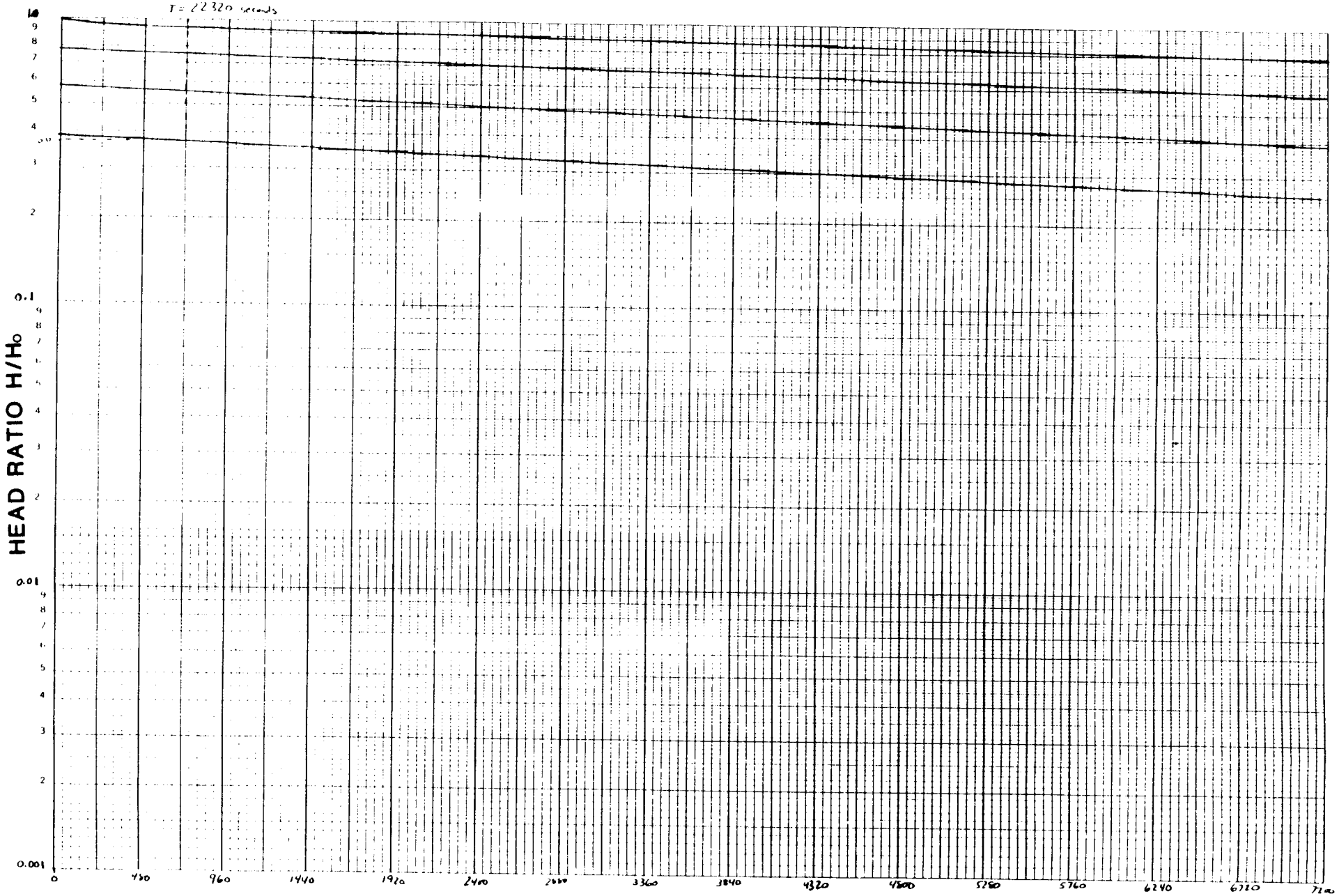
WELL S 64 (9-11')

NUS CORPORATION

A Halliburton Company

Well S-64 (19-21')
GW level from ground surface = 4.0'
Casing stick up from ground level = 3.5'
Depth of borehole below ground level = 21.0'
Casing diameter = 3.0"
H_o = 90.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	90.00	1.00	720	84.25	0.94
30	89.00	0.99	780	84.13	0.93
60	88.25	0.98	840	84.00	0.93
90	87.85	0.98	900	83.88	0.93
120	87.38	0.97	1200	83.25	0.93
150	87.25	0.97	1500	83.00	0.92
180	87.00	0.97	1800	82.63	0.92
210	86.75	0.96	2100	82.00	0.91
240	86.63	0.96	2400	81.50	0.91
270	86.25	0.96			
300	86.00	0.96			
360	85.87	0.95			
420	85.38	0.95			
480	85.13	0.95			
540	84.88	0.94			
600	84.75	0.94			
660	84.38	0.94			



DRAWDOWN CURVE

H/Ho vs TIME

WELL S 64 (19-21')

NUS CORPORATION

A Halliburton Company

Well No. S-64 (31.5-33.5') Brown silty sand, little clay and gravel.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 1590$ sec

$K = \frac{\pi (7.62)}{11 (1590)}$

$K = 1.37 \times 10^{-3}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (2700)} \ln \frac{163.0}{32.3}$

$K = 1.30 \times 10^{-3}$ cm/sec

$D = 7.62$ cm
$t_2 = 2700$ sec
$t_1 = 0$
$H_1 = 163.0$ cm
$H_2 = 32.3$ cm

Well No. S-74 (39-41') Brown sand, little silt.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 48$ sec

$K = \frac{\pi (7.62)}{11 (48)}$

$K = 4.5 \times 10^{-2}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (660)} \ln \frac{150.3}{0.30}$

$K = 2.0 \times 10^{-2}$ cm/sec

$D = 7.62$ cm
$t_2 = 660$ sec.
$t_1 = 0$
$H_1 = 150.3$ cm
$H_2 = 0.30$ cm

Well No. S-74 (54-56') Brown silty sand, trace clay.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 36$ sec

$K = \frac{\pi (7.62)}{11 (36)}$

$K = 6.0 \times 10^{-2}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

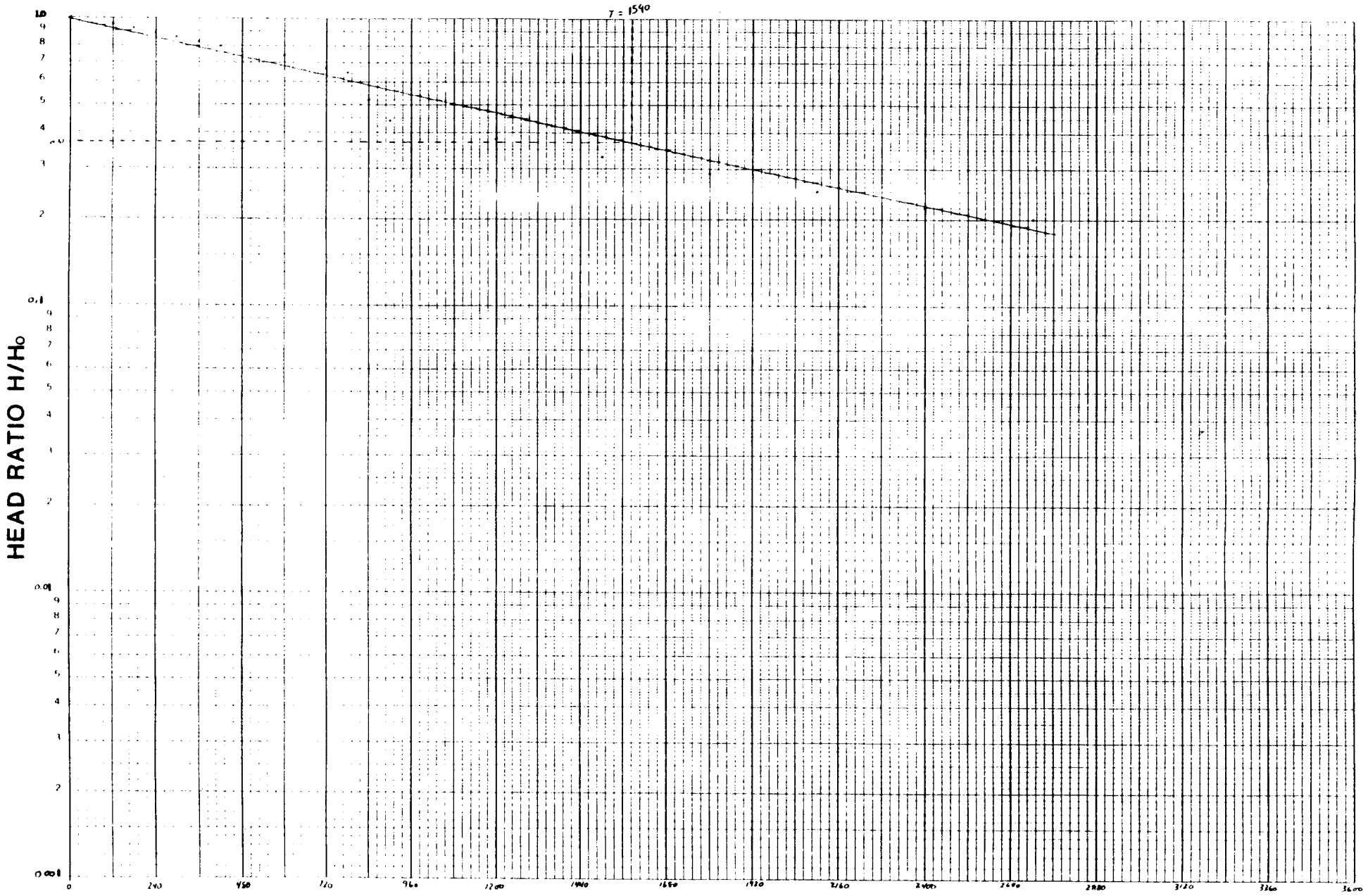
$K = \frac{\pi (7.62)}{11 (150)} \ln \frac{150.8}{0.10}$

$K = 1.0 \times 10^{-1}$ cm/sec

$D = 7.62$ cm
$t_2 = 150$ sec.
$t_1 = 0$
$H_1 = 150.8$ cm
$H_2 = 0.10$ cm

Well S-64 (31.5-33.5')
GW level from ground surface = 4.0'
Casing stick up from ground level = 1.35'
Depth of borehole below ground level = 33.5'
Casing diameter = 3.0"
H_o = 64.2"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	64.20	1.00	720	43.08	0.67
30	63.12	0.98	780	41.64	0.65
60	-	-	840	33.24	0.52
90	62.04	0.97	900	28.44	0.44
120	61.20	0.95	1200	24.12	0.38
150	60.00	0.93	1500	21.24	0.33
180	58.80	0.92	1800	18.60	0.29
210	57.72	0.90	2100	16.32	0.25
240	56.76	0.88	2400	14.40	0.22
270	55.80	0.87	2700	12.72	0.20
300	54.96	0.86	3000	-	-
360	53.04	0.83			
420	51.24	0.80			
480	-	-			
540	47.40	0.74			
600	45.50	0.71			
660	44.52	0.69			



DRAWDOWN CURVE

H/H₀ vs TIME

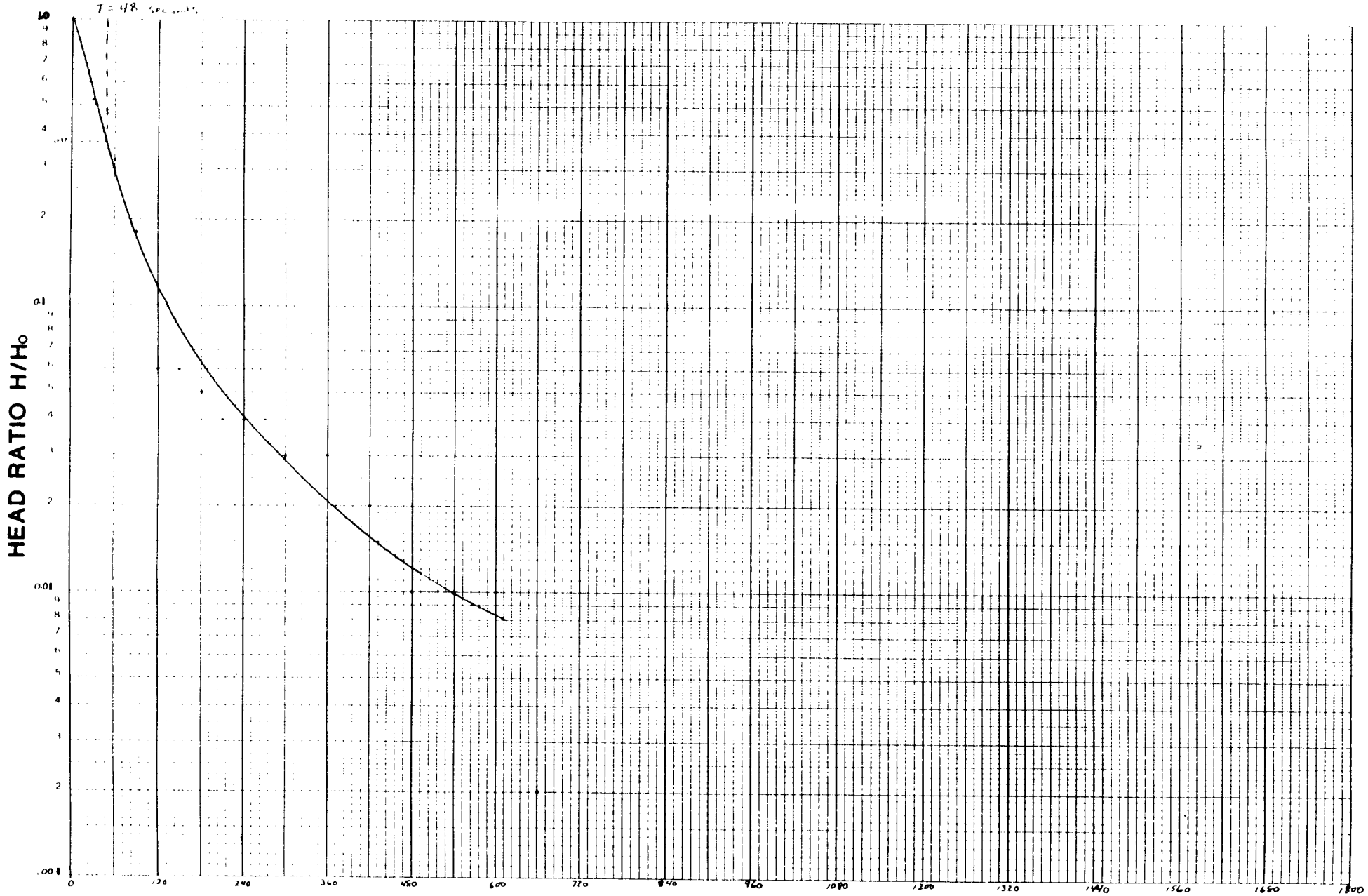
WELL S 64 (31.5-33.5)

NUS CORPORATION

A Halliburton Company

Wells S-74 (39-41')
GW level from ground surface = 1.5'
Casing stick up from ground level = 3.43'
Depth of borehole below ground level = 41.0'
Casing diameter = 3.0"
H_o = 59.16"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	-	1.00			
30	30.96	0.52			
60	19.08	0.32			
90	11.16	0.18			
120	3.36	0.06			
150	3.36	0.06			
180	2.76	0.05			
210	2.64	0.04			
240	2.28	0.04			
270	2.16	0.04			
300	1.80	0.03			
360	1.56	0.03			
420	0.96	0.02			
480	0.36	0.01			
540	0.36	0.01			
600	0.36	0.01			
660	0.12	0.002			



TIME (T) SECONDS

DRAWDOWN CURVE

H/H_0 vs TIME

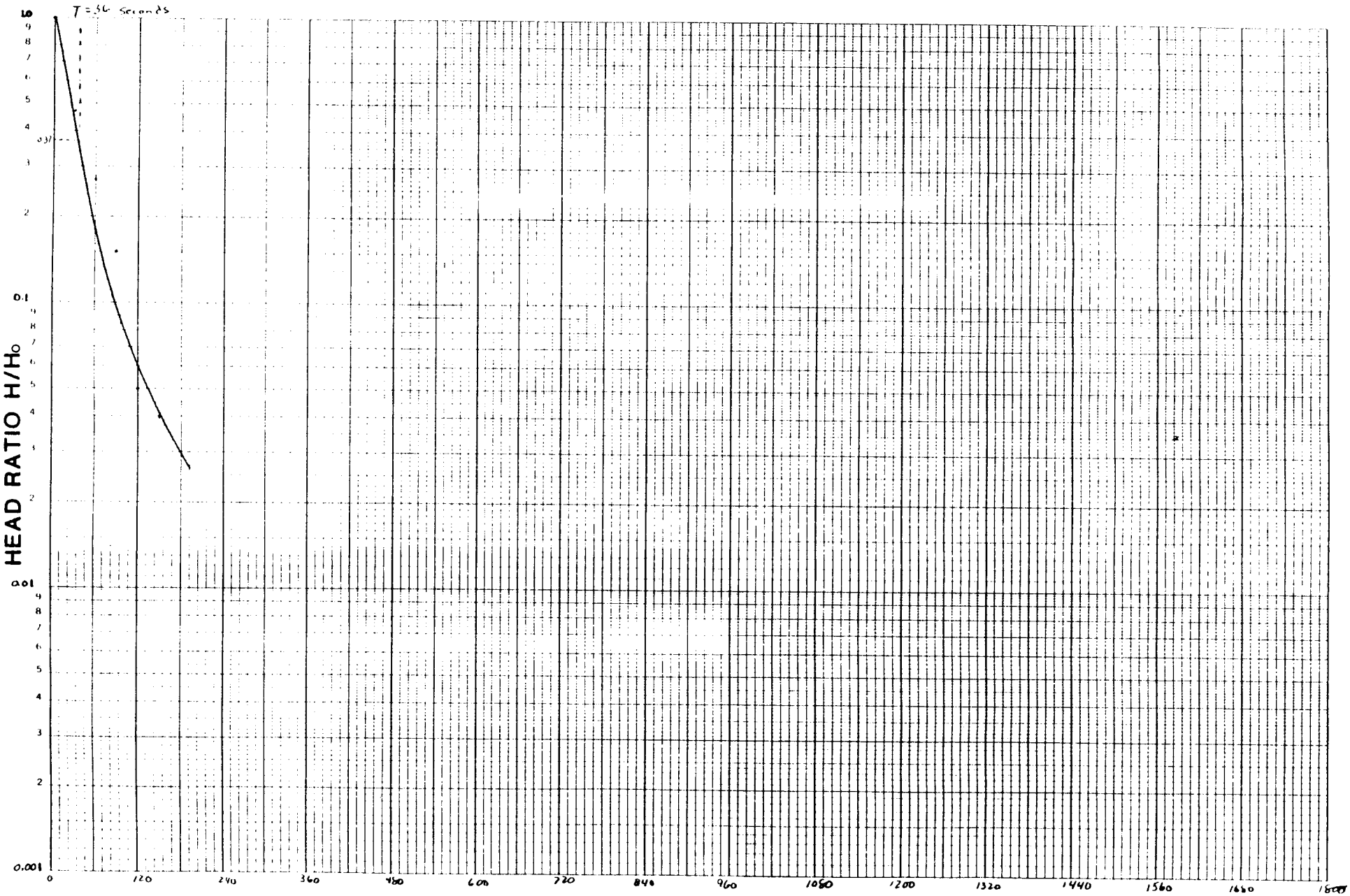
WELL S 74 (39-41')

NUS CORPORATION

A Halliburton Company

WEll S-74 (54-56')
GW level from ground surface = 1.5'
Casing stick up from ground level = 3.45'
Depth of borehole below ground level = 56.0'
Casing diameter = 3.0"
H_o = 59.40"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	59.40	1.00			
30	27.96	0.47			
60	16.20	0.27			
90	8.76	0.15			
120	3.24	0.0			
150	2.40	0.04			
180	0.00	0			



TIME (T) SECONDS DRAWDOWN CURVE

H/H_o vs TIME

WELL S 74 (54-56')

NUS CORPORATION

A Halliburton Company

Well No. S-74 (66-68') Running sands, no sample collected.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 11220$ sec

$K = \frac{\pi (7.62)}{11 (11220)}$

$K = 1.94 \times 10^{-4}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (3900)} \ln \frac{150.8}{114.6}$

$K = 1.53 \times 10^{-4}$ cm/sec

$D = 7.62$ cm
$t_2 = 3900$ sec
$t_1 = 0$
$H_1 = 150.8$ cm
$H_2 = 114.6$ cm

Well No. S-76 (20-22') Brown silty sand, trace clay.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 74400$ sec

$K = \frac{\pi (7.62)}{11 (74400)}$

$K = 2.93 \times 10^{-5}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (5400)} \ln \frac{365.7}{342.6}$

$K = 2.63 \times 10^{-5}$ cm/sec

$D = 7.62$ cm
$t_2 = 5400$ sec
$t_1 = 0$
$H_1 = 365.7$ cm
$H_2 = 342.6$ cm

Well No. S-76 (60-62') Brown silty sand, trace clay.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 57360$ sec

$K = \frac{\pi (7.62)}{11 (57360)}$

$K = 3.8 \times 10^{-5}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

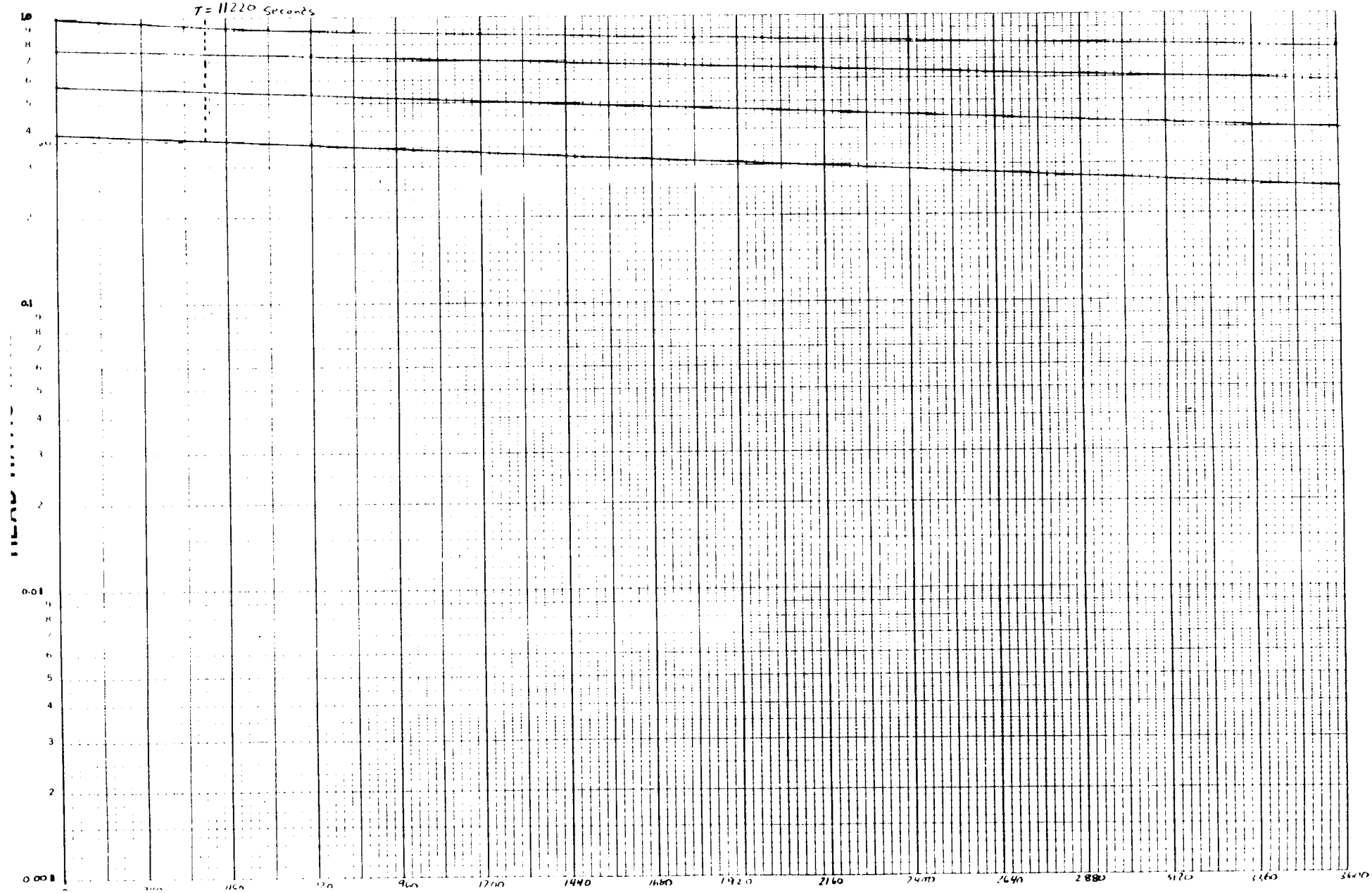
$K = \frac{\pi (7.62)}{11 (8400)} \ln \frac{365.7}{302.4}$

$K = 4.93 \times 10^{-5}$ cm/sec

$D = 7.62$ cm
$t_2 = 8400$ sec
$t_1 = 0$
$H_1 = 365.7$ cm
$H_2 = 302.4$ cm

Well S-74 (66-68')
GW level from ground surface = 1.5'
Casing stick up from ground level = 3.45'
Depth of borehole below ground level = 68.0'
Casing diameter = 3.0"
H_o = 59.4"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	59.40	1.00	720	53.52	0.90
30	58.80	0.99	780	53.28	0.90
60	58.20	0.98	840	52.80	0.89
90	57.60	0.97	900	52.56	0.88
120	57.48	0.97	1200	51.60	0.87
150	57.48	0.97	1500	50.4	0.85
180	57.24	0.96	1800	49.56	0.83
210	57.12	0.96	2100	48.84	0.82
240	56.88	0.96	2400	48.12	0.81
270	56.40	0.95	2700	47.40	0.80
300	55.80	0.94	3000	46.80	0.79
360	55.44	0.93	3300	46.44	0.78
420	55.32	0.93	3600	45.72	0.77
480	54.84	0.92	3900	45.12	0.76
540	54.48	0.92			
600	54.12	0.91			
660	53.68	0.91			



TIME (T) SECONDS

DRAWDOWN CURVE

H/H_o vs TIME

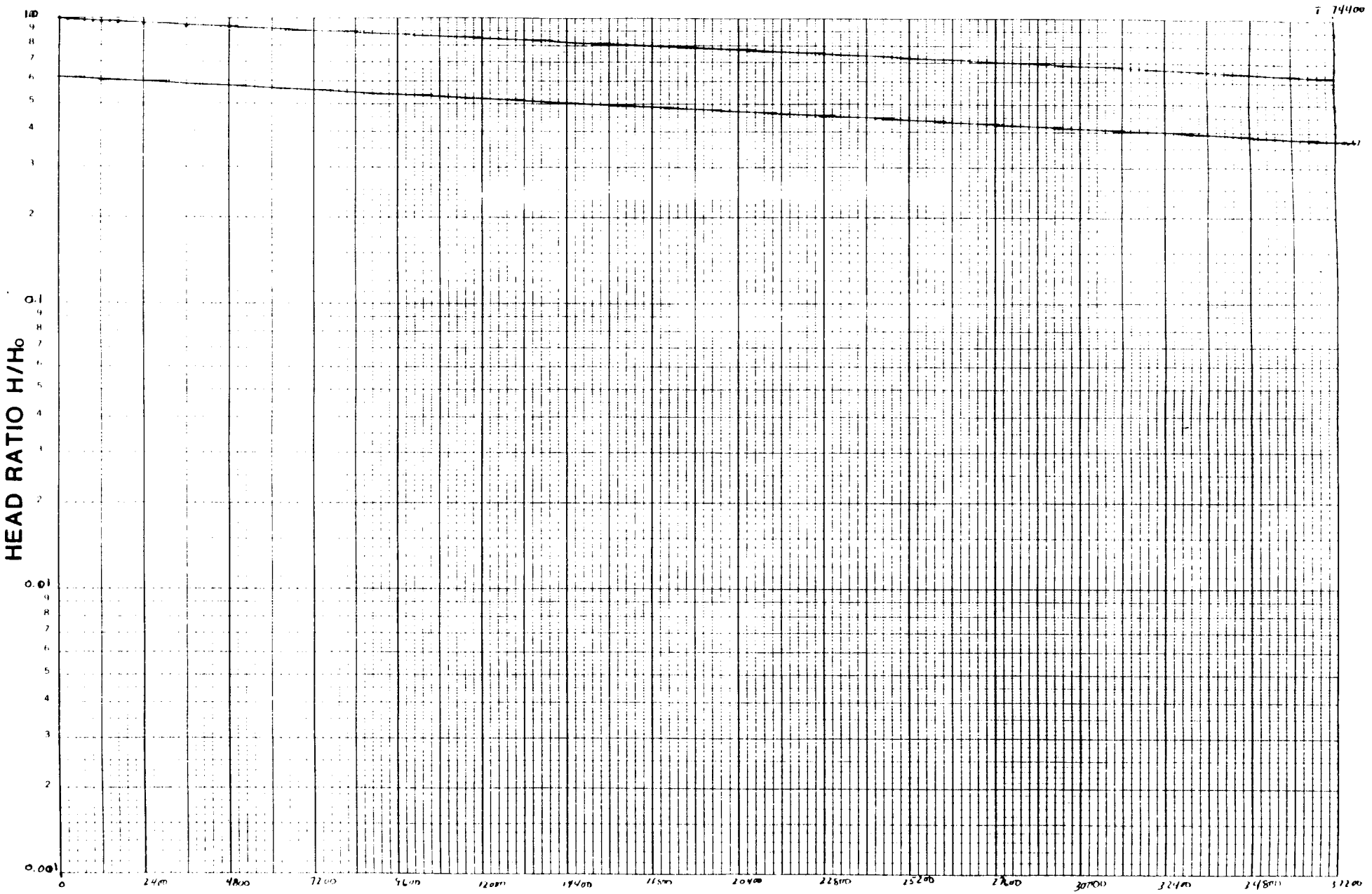
WELL S 74 (66-68')

NUS CORPORATION

A Halliburton Company

Well S-76 (20-22')
GW level from ground surface = 11.0'
Casing stick up from ground level = 1.0'
Depth of borehole below ground level = 22.0'
Casing diameter = 3.0"
H_o = 144.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	144.00	1.00	600	141.60	0.98
30	143.75	0.99	660	141.50	0.98
60	143.75	0.99	720	141.40	0.98
90	143.00	0.99	780	141.25	0.98
120	143.00	0.99	840	141.10	0.98
150	142.90	0.99	900	141.00	0.98
180	142.90	0.99	960	140.16	0.97
210	142.70	0.99	1020	139.92	0.97
240	142.60	0.99	1080	139.80	0.97
270	142.50	0.99	1140	139.68	0.97
300	142.40	0.99	1200	139.56	0.97
330	142.30	0.99	1260	139.32	0.97
360	142.25	0.99	1320	139.20	0.97
390	142.20	0.99	1380	139.08	0.97
420	142.10	0.99	1440	138.96	0.97
480	141.9	0.99	1500	138.84	0.96
540	141.6	0.98	1560	138.72	0.96



DRAWDOWN CURVE

H/Ho vs TIME

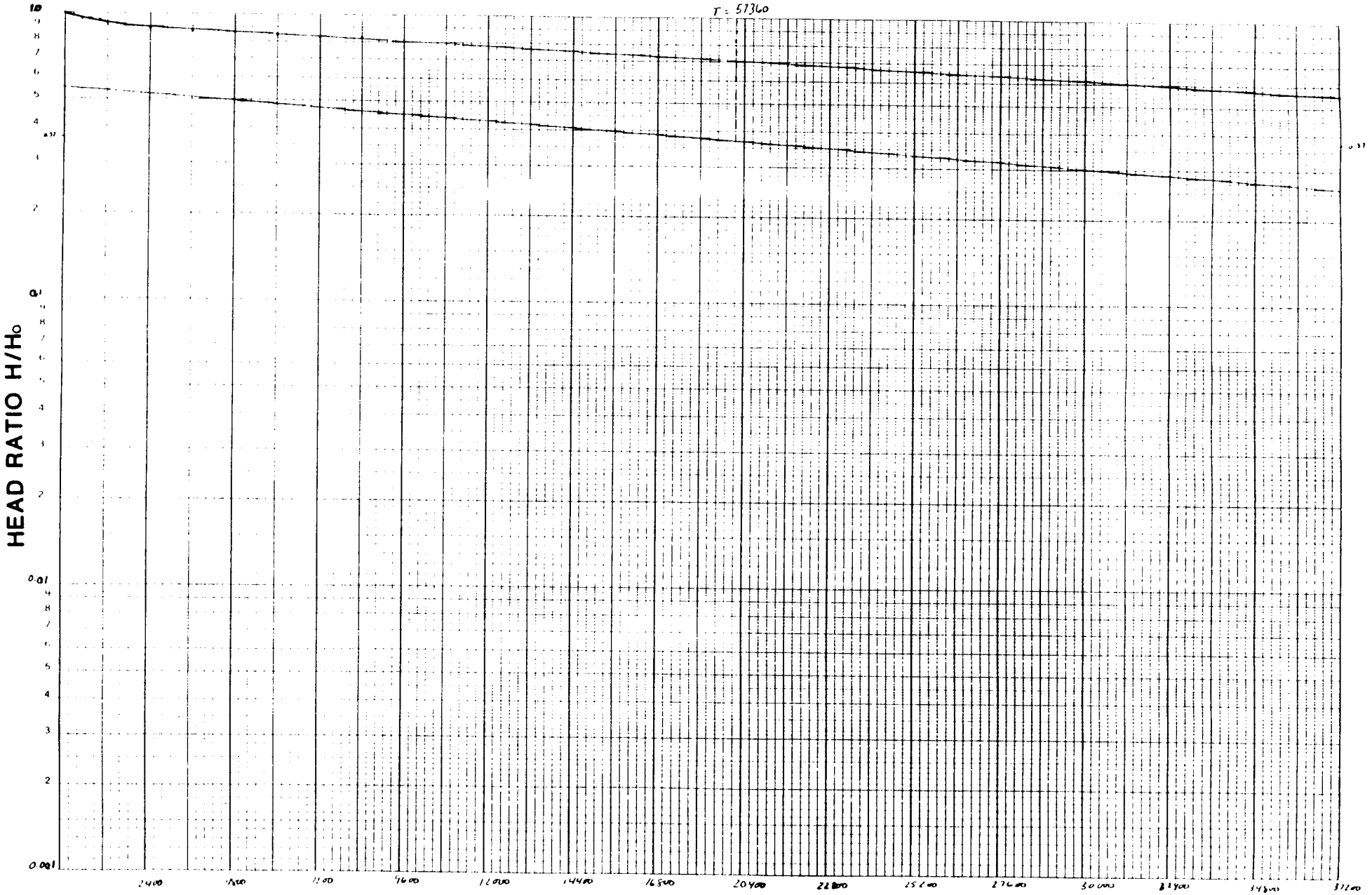
WELL S 76 (20-22')

NUS CORPORATION

A Halliburton Company

Well S-76 (60-62')
GW level from ground surface = 11.0'
Casing stick up from ground level = 1.0'
Depth of borehole below ground level = 62.0
Casing diameter = 3.0"
H_o = 144.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	144	1.00	720	136.80	0.95
30	143.40	1.00	780	136.32	0.95
60	142.92	0.99	840	135.72	0.94
90	142.56	0.99	900	135.24	0.94
120	142.32	0.99	960	135.00	0.94
150	141.96	0.96	1020	134.64	0.94
180	141.60	0.98	1080	134.28	0.93
210	141.24	0.91	1140	133.92	0.93
240	141.12	0.98	1200	132.84	0.92
270	140.88	0.98	1260	132.24	0.92
300	140.40	0.98	1320	131.88	0.92
360	139.80	0.97	1380	131.82	0.92
420	139.20	0.97	1440	131.76	0.92
480	138.72	0.96	1500	131.64	0.91
540	138.36	0.96	1560	131.40	0.91
600	137.88	0.96	1620	131.04	0.91
660	137.40	0.95	1680	130.92	0.91



DRAWDOWN CURVE

H/Ho vs TIME

WELL S 76 (60-62')

NUS CORPORATION

Well No. S-76 (126-128') No soil sample collected.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 77760$ sec

$K = \frac{\pi (7.62)}{11 (77760)}$

$K = 2.8 \times 10^{-6}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (7200)} \ln \frac{365.7}{323.4}$

$K = 3.72 \times 10^{-5}$ cm/sec

$D = 7.62$ cm
$t_2 = 7200$ sec
$t_1 = 0$
$H_1 = 365.7$ cm
$H_2 = 323.4$ cm

Well No. S-77 (30-32') Red-brown medium-coarse sand, some fine sand, trace silt.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 60000$ sec

$K = \frac{\pi (7.62)}{11 (60000)}$

$K = 3.6 \times 10^{-5}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (3600)} \ln \frac{213.4}{200.0}$

$K = 3.9 \times 10^{-5}$ cm/sec

$D = 7.62$ cm
$t_2 = 3600$ sec
$t_1 = 0$
$H_1 = 213.4$ cm
$H_2 = 200.0$ cm

Well No. S-77 (73-75') Brown sand, trace gravel.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 24960$ sec

$K = \frac{\pi (7.62)}{11 (24960)}$

$K = 8.7 \times 10^{-5}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

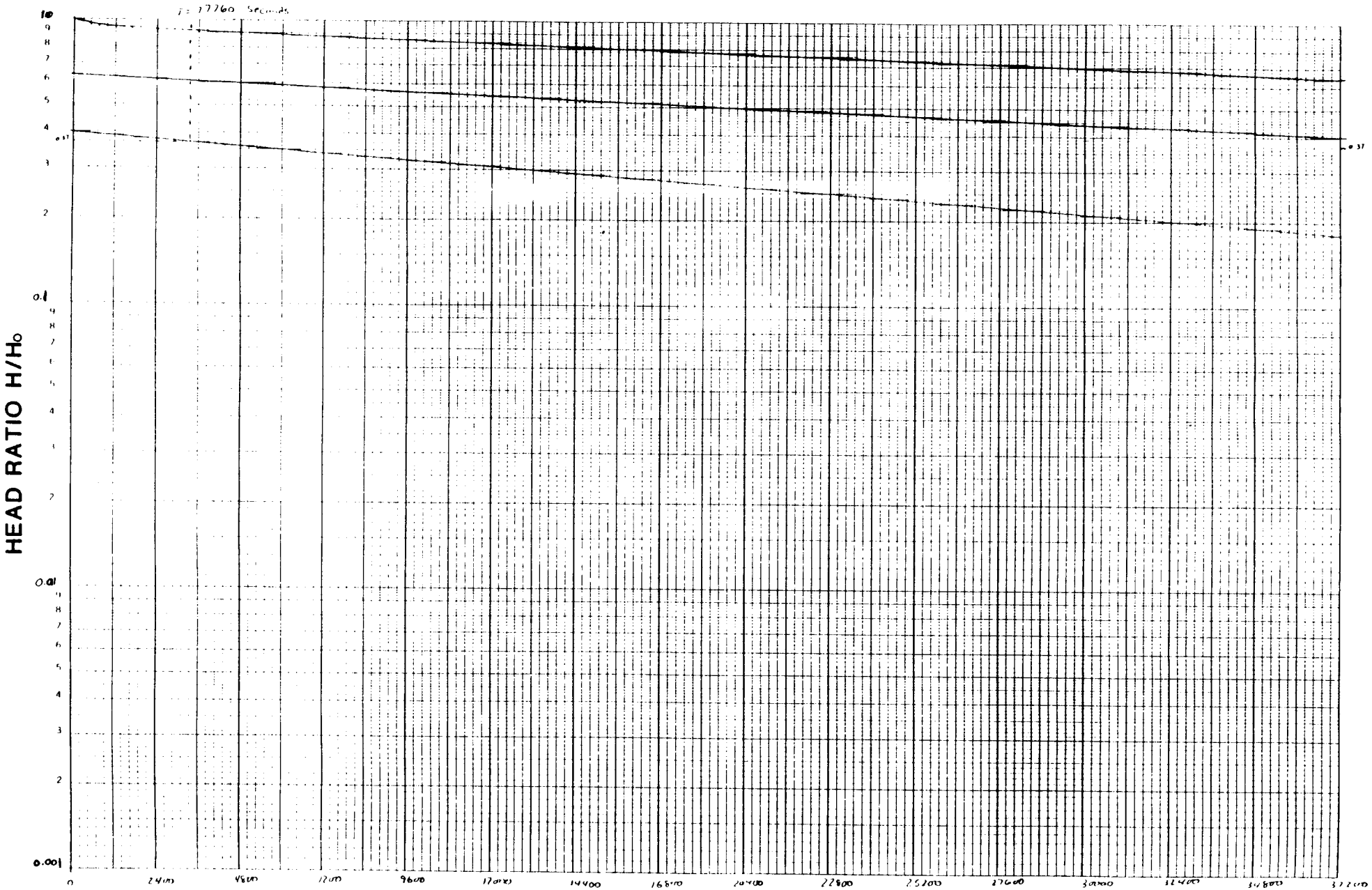
$K = \frac{\pi (7.62)}{11 (3600)} \ln \frac{213.4}{172.7}$

$K = 1.27 \times 10^{-4}$ cm/sec

$D = 7.62$ cm
$t_2 = 3600$ sec
$t_1 = 0$
$H_1 = 213.4$ cm
$H_2 = 172.7$ cm

Well S-76 (126-128')
GW level from ground surface = 11.0'
Casing stick up from ground level = 1.0'
Depth of borehole below ground level = 128.0'
Casing diameter = 3.0"
H_o = 144.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	144	1.00	720	137.40	0.95
30	143,16	0.99	780	137.16	0.95
60	142.68	0.99	840	136.80	0.95
90	142.2	0.99	900	136.68	0.95
120	141.72	0.98	960	136.44	0.95
150	141.48	0.98	1020	136.20	0.95
180	141.24	0.98	1080	135.84	0.94
210	140.88	0.98	1140	135.72	0.94
240	140.52	0.98	1200	135.48	0.94
270	140.40	0.98	1260	135.12	0.94
300	139.92	0.97	1320	135.00	0.94
360	139.68	0.97	1380	135.00	0.94
420	139.20	0.97	1440	134.76	0.94
480	138.84	0.96	1500	134.64	0.94
540	138.36	0.96	1560	134.40	0.93
600	138.00	0.96	1620	134.16	0.93
660	137.52	0.96	1680	134.04	0.93



DRAWDOWN CURVE

H/Ho vs TIME

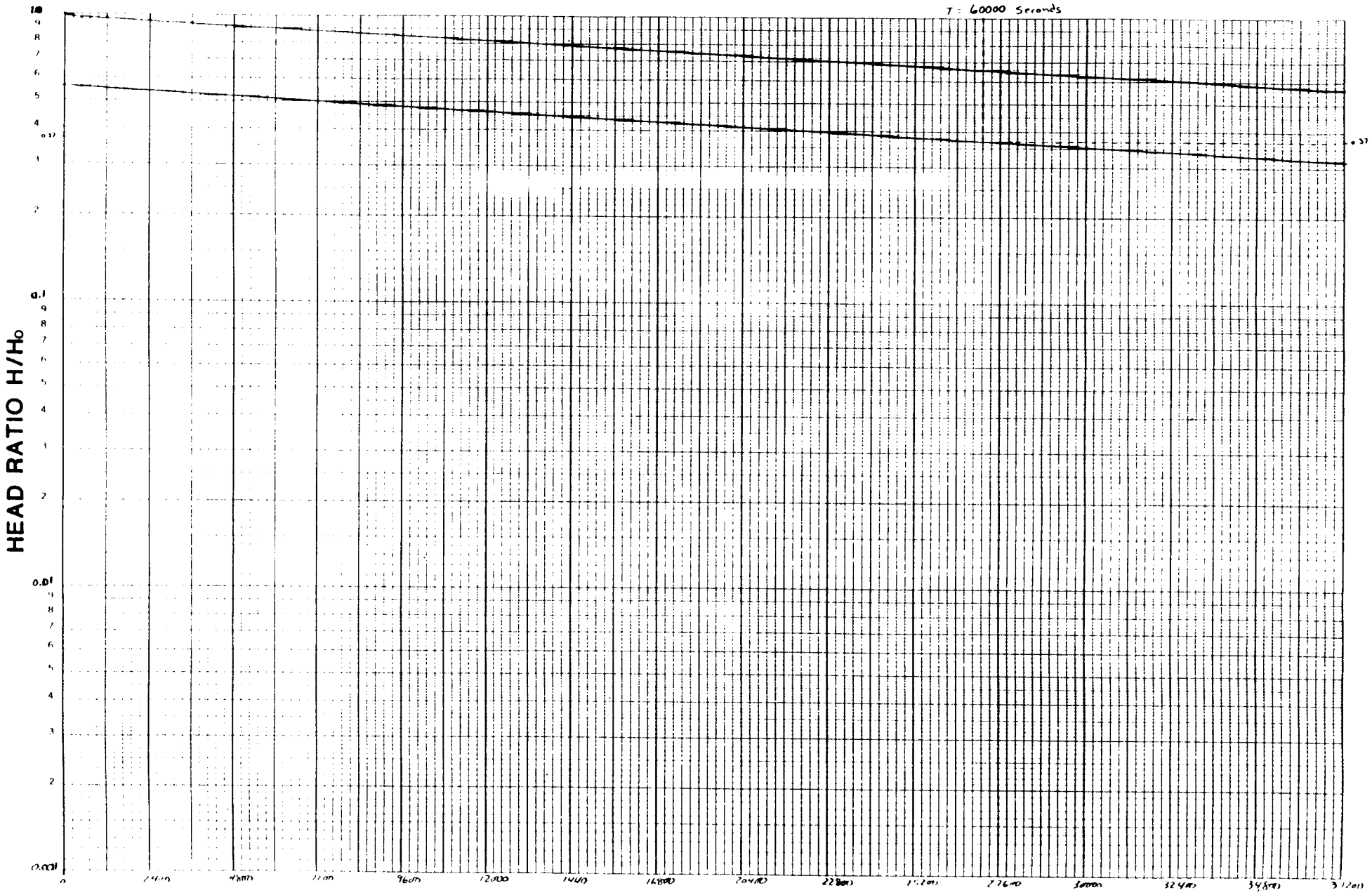
WELL S 76 (126-128')

NUS CORPORATION

A Halliburton Company

Well S-77 (30-32')
GW level from ground surface = 5.0'
Casing stick up from ground level = 2.0'
Depth of borehole below ground level = 32.0'
Casing diameter = 3.0"
H_o = 84.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	84.00	1.00	720	81.50	0.97
30	83.5	0.99	780	81.50	0.97
60	83.12	0.99	840	81.37	0.97
90	83.00	0.99	900	81.25	0.97
120	82.87	0.99	1200	81.12	0.97
150	82.75	0.99	1500	80.50	0.96
180	82.62	0.98	1800	80.25	0.96
210	82.50	0.98	2100	80.00	0.95
240	82.37	0.98	24.00	79.75	0.95
270	82.25	0.98	2700	79.50	0.95
300	82.12	0.98	3000	79.25	0.94
360	82.00	0.98	3300	79.00	0.94
420	82.00	0.98	3600	78.75	0.94
480	81.87	0.97			
540	81.87	0.97			
600	81.75	0.97			
660	81.62	0.97			



DRAWDOWN CURVE

H/Ho vs TIME

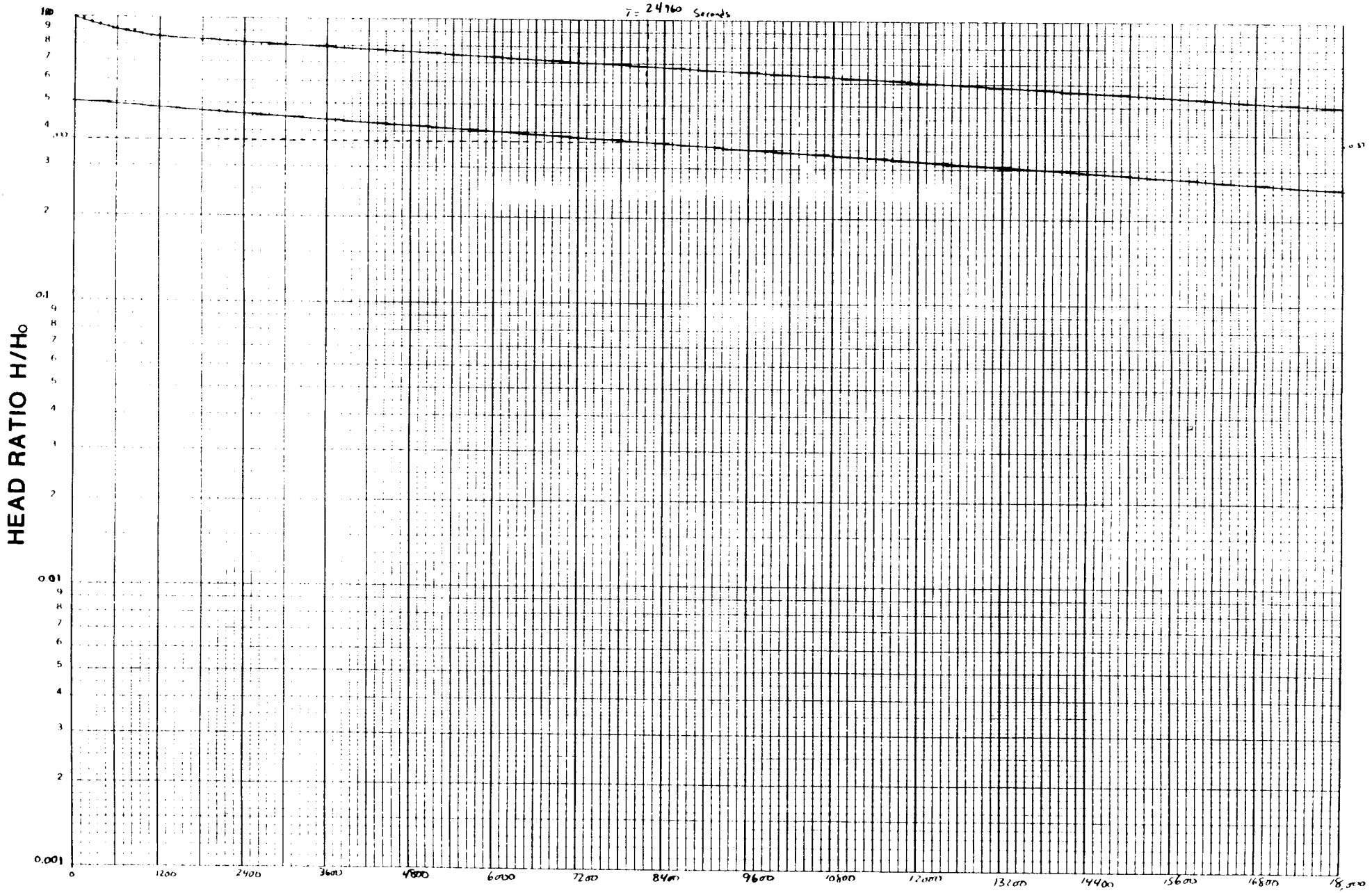
WELL S 77 (30-32')

NUS CORPORATION

A Halliburton Company

Well S-77 (73-75')
GW level from ground surface = 5.0'
Casing stick up from ground level = 2.0'
Depth of borehole below ground level = 75.0'
Casing diameter = 3.0"
H_o = 84.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	84.00	1.00	510	77.25	0.92
30	83.40	0.99	540	77.00	0.92
60	83.00	0.99	570	76.62	0.91
90	82.62	0.98	600	76.25	0.91
120	82.25	0.98	660	75.75	0.90
150	81.62	0.97	720	75.12	0.89
180	01.37	0.97	780	74.75	0.89
210	81.00	0.96	840	74.37	0.89
240	80.75	0.96	900	73.87	0.88
270	80.25	0.96	960	73.37	0.87
300	79.75	0.95	1020	73.00	0.87
330	79.37	0.94	1080	72.62	0.86
360	79.00	0.94	1140	72.50	0.86
390	78.75	0.94	1200	72.12	0.86
420	78.50	0.93	1500	71.00	0.85
450	78.12	0.93	1800	70.00	0.83
480	77.50	0.92	2100	69.50	0.83



TIME (T) SECONDS

DRAWDOWN CURVE

H/H_0 vs TIME

WELL S 77 (73-75')

NUS CORPORATION

A Halliburton Company

Well No. S-84 (16-18') Brown sand, some gravel.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 80160$ sec

$K = \frac{\pi (7.62)}{11 (80160)}$

$K = 2.7 \times 10^{-5}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (3900)} \ln \frac{213.4}{203.5}$

$K = 2.63 \times 10^{-5}$ cm/sec

$D = 7.62$ cm
$t_2 = 3900$ sec
$t_1 = 0$
$H_1 = 213.4$ cm
$H_2 = 203.5$ cm

Well No. S-84 (78-80') Brown gravel and sand, trace silt.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 19680$ sec

$K = \frac{\pi (7.62)}{11 (19680)}$

$K = 1.1 \times 10^{-4}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (3600)} \ln \frac{213.4}{177.8}$

$K = 1.1 \times 10^{-4}$ cm/sec

$D = 7.62$ cm
$t_2 = 3600$ sec
$t_1 = 0$
$H_1 = 213.4$ cm
$H_2 = 177.8$ cm

Well No. S-85 (15-17') Light gray fine sand.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 4050$ sec

$K = \frac{\pi (7.62)}{11 (4050)}$

$K = 5.37 \times 10^{-4}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

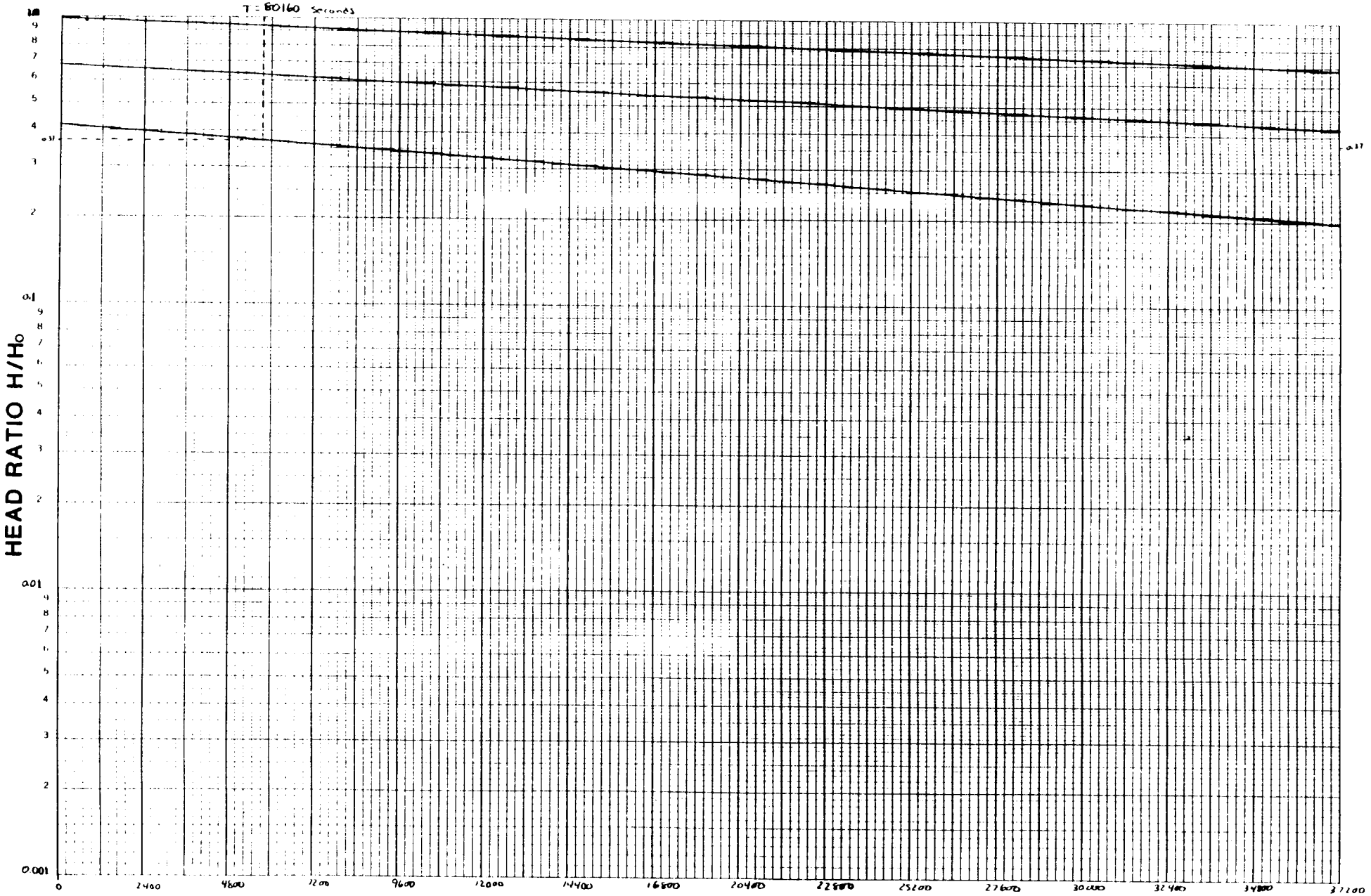
$K = \frac{\pi (7.62)}{11 (3630)} \ln \frac{106.7}{44.0}$

$K = 5.30 \times 10^{-4}$ cm/sec

$D = 7.62$ cm
$t_2 = 3630$ sec
$t_1 = 0$
$H_1 = 106.7$ cm
$H_2 = 44.0$ cm

Well S-84 (16-18')
GW level from ground surface = 5.0'
Casing stick up from ground level = 2.0'
Depth of borehole below ground level = 18.0'
Casing diameter = 3.0"
H_o = 84.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	84"	1.00	720	82.56	0.98
30	83.94	1.00	780	82.50	0.98
60	83.75	1.00	840	82.50	0.98
90	83.62	1.00	900	82.44	0.98
120	83.50	0.99	1200	82.12	0.98
150	83.37	0.99	1500	82.00	0.98
180	83.37	0.99	1800	81.81	0.97
210	83.25	0.99	2100	81.75	0.97
240	83.12	0.99	2400	81.50	0.97
270	83.12	0.99	2700	81.37	0.97
300	83.12	0.99	3000	80.50	0.96
360	83.00	0.99	3300	80.62	0.96
420	83.00	0.99	3600	80.37	0.96
480	82.87	0.99	3900	80.12	0.95
540	82.75	0.99			
600	82.69	0.98			
660	82.62	0.98			



TIME (T) SECONDS

DRAWDOWN CURVE

H/H₀ vs TIME

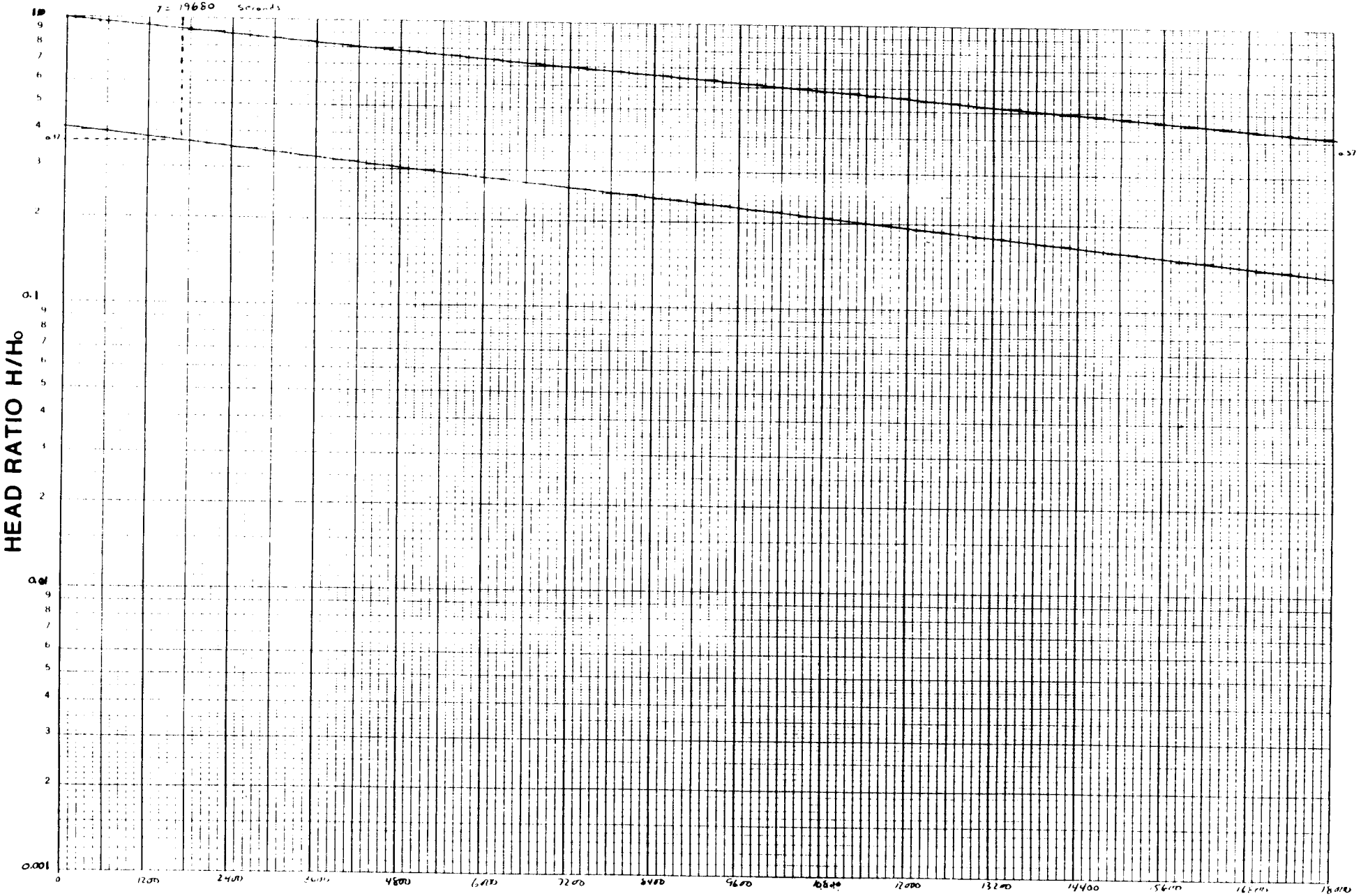
WELL S 84 (16-18')

NUS CORPORATION

A Halliburton Company

Well S-84 (78-80')
GW level from ground surface = 5.0'
Casing stick up from ground level = 2.0'
Depth of borehole below ground level = 80.0'
Casing diameter = 3.0"
H_o = 84.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	84.00	1.00	1200	79.62	0.95
30	84.00	1.00	1500	78.00	0.93
60	83.87	1.00	1800	76.87	0.92
90	83.75	1.00	2100	75.00	0.89
120	83.62	1.00	2400	74.00	0.88
150	83.37	0.99	2700	73.00	0.87
180	83.00	0.99	3000	72.00	0.86
210	82.87	0.99	3300	71.00	0.85
240	82.81	0.99	3600	70.00	0.83
270	82.75	0.99			
300	82.63	0.98			
360	82.13	0.98			
420	82.00	0.98			
480	81.87	0.97			
540	81.75	0.97			
600	81.50	0.97			
900	81.37	0.97			



DRAWDOWN CURVE

H/Ho vs TIME

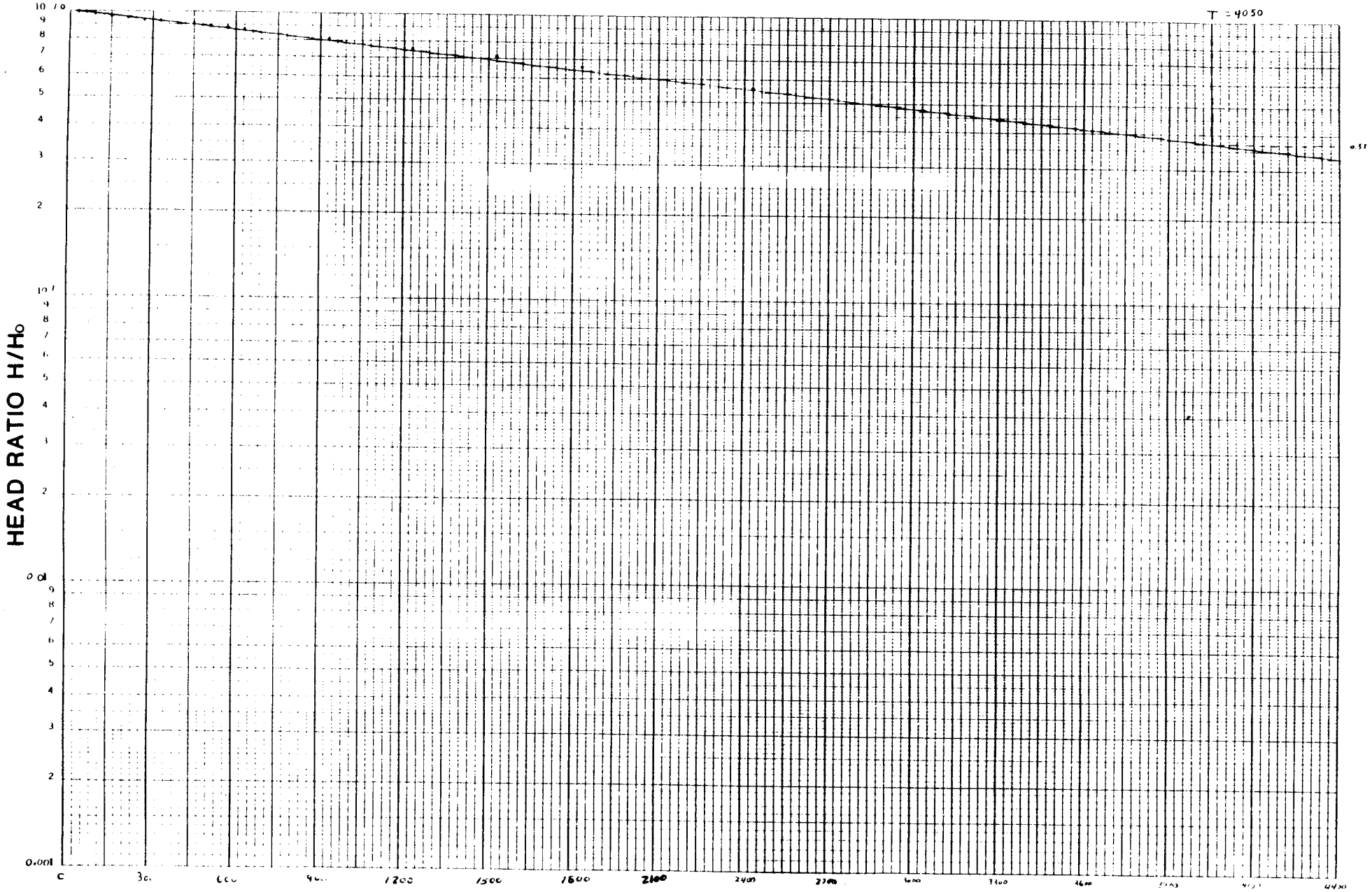
WELL S 84 (78-80')

NUS CORPORATION

A Halliburton Company

Well S-85 (15-17')
GW level from TOC = 3.5'
Casing stick up from ground level = 2.5'
Depth of borehole below ground level = 17.0'
Casing diameter = 3.0"
H_o = 42.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	42.00	1.00	930	34.12	0.81
30	41.88	1.00	1230	31.62	0.75
60	41.75	0.99	1530	29.62	0.71
90	41.00	0.98	1830	27.87	0.66
120	40.62	0.97	2430	23.62	0.56
150	40.37	0.96	3030	20.12	0.48
180	40.25	0.96	3630	17.32	0.41
210	40.00	0.95			
240	39.75	0.95			
270	39.25	0.93			
300	39.12	0.93			
330	39.00	0.93			
390	38.50	0.92			
450	38.12	0.91			
510	37.25	0.89			
570	36.50	0.87			
630	36.5	0.87			



DRAWDOWN CURVE

H/Ho vs TIME

WELL S 85 (15-17')

NUS CORPORATION

A Halliburton Company

Well No. S-85 (35-37') Brown sand, some gravel.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 16080$ sec

$K = \frac{\pi (7.62)}{11 (16080)}$

$K = 1.35 \times 10^{-4}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

$K = \frac{\pi (7.62)}{11 (3600)} \ln \frac{106.7}{75.2}$

$K = 2.11 \times 10^{-4}$ cm/sec

$D = 7.62$ cm
$t_2 = 3600$ sec
$t_1 = 0$
$H_1 = 106.7$ cm
$H_2 = 75.2$ cm

Well No. S-86 (50-52') Brown sand, trace gravel and silt.

Basic Time Lag

$K = \frac{\pi D}{11 T}$ $\quad D = 7.62$ cm, $T = 21000$ sec

$K = \frac{\pi (7.62)}{11 (21000)}$

$K = 1.04 \times 10^{-4}$ cm/sec

Falling Head

$K = \frac{\pi D}{11 (t_2 - t_1)} \ln \frac{H_1}{H_2}$

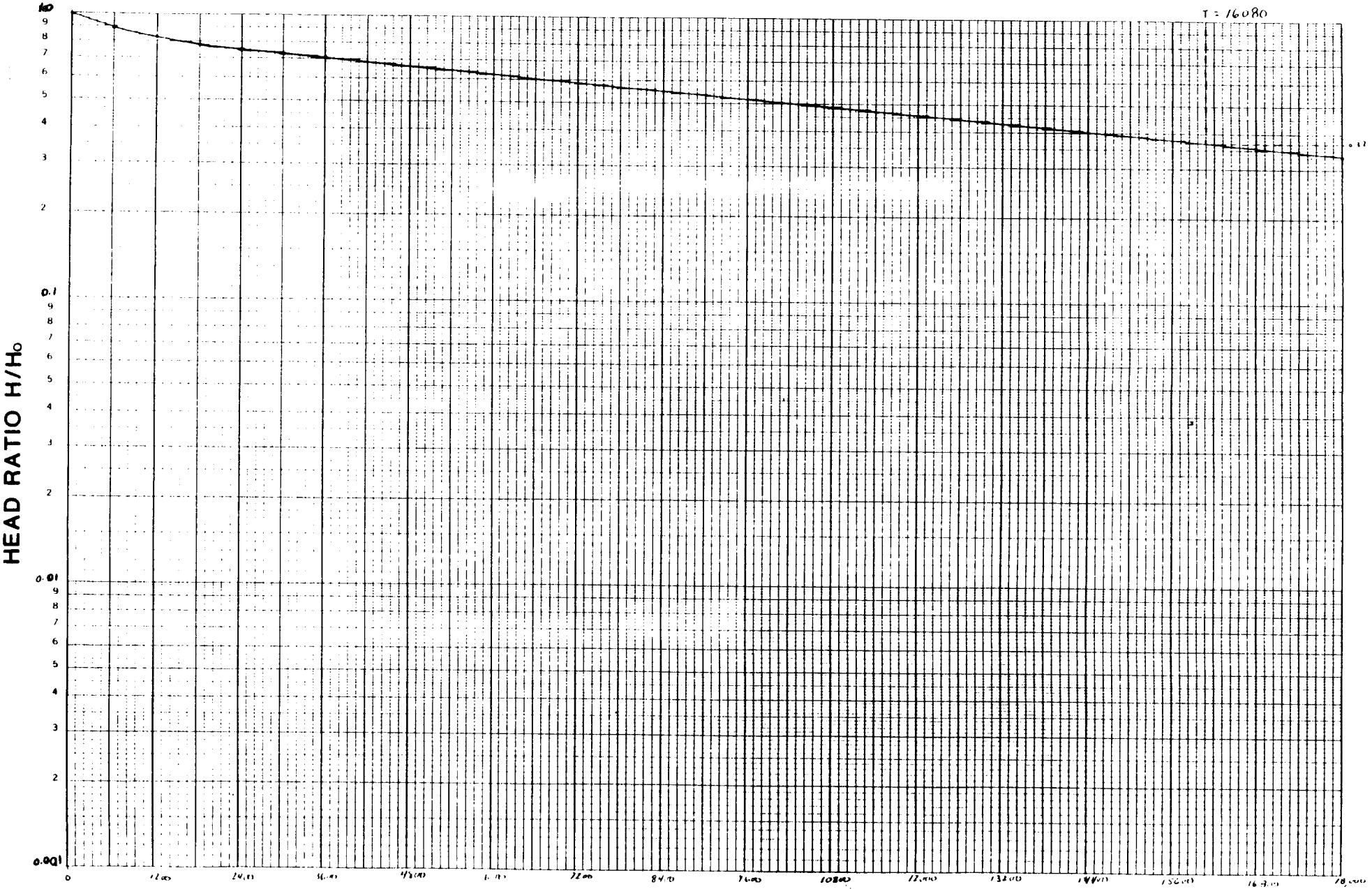
$K = \frac{\pi (7.62)}{11 (3600)} \ln \frac{137.2}{107.0}$

$K = 1.50 \times 10^{-4}$ cm/sec

$D = 7.62$ cm
$t_2 = 3600$ sec
$t_1 = 0$
$H_1 = 137.2$ cm
$H_2 = 107.0$ cm

Well S-85 (35-37')
GW level from TOC = 3.5'
Casing stick up from ground level = 2.68'
Depth of borehole below ground level = 37.0'
Casing diameter = 3.0"
H_o = 42.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	42.00	1.00	1200	34.75	0.83
30	41.75	0.99	1500	33.75	0.80
60	40.87	0.97	1800	32.87	0.78
90	40.25	0.96	2400	31.62	0.75
120	39.87	0.95	3000	30.50	0.73
150	39.62	0.94	3600	29.62	0.71
180	39.32	0.94			
210	39.25	0.93			
240	39.12	0.93			
270	39.00	0.93			
300	38.87	0.93			
360	38.50	0.92			
420	38.12	0.91			
480	38.00	0.90			
540	37.62	0.90			
600	37.25	0.89			
900	36.00	0.85			



DRAWDOWN CURVE

H/H₀ vs TIME

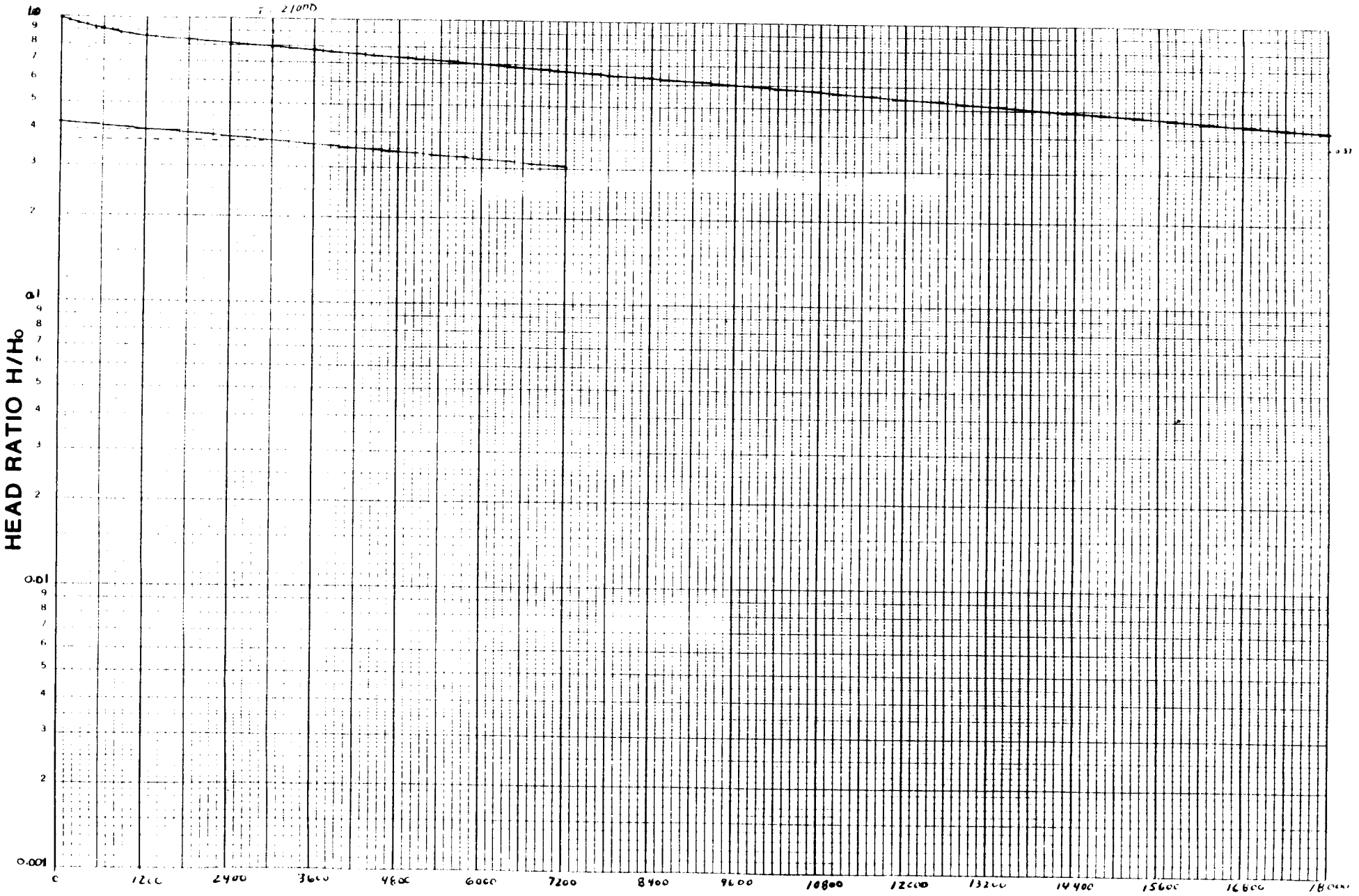
WELL S 85 (35-37')

NUS CORPORATION

A Halliburton Company

Well S-86 (50-52')
GW level from ground surface = 2.0'
Casing stick up from ground level = 2.5'
Depth of borehole below ground level = 52.0'
Casing diameter = 3.0"
H_o = 54.0"

Time (t) (seconds)	H (inches)	H/H_o	Time (t) (seconds)	H (inches)	H/H_o
0	54	1.00	720	48.50	0.90
30	53.50	0.99	780	48.00	0.89
60	53.00	0.98	840	47.75	0.88
90	52.87	0.98	900	47.50	0.88
120	52.62	0.97	1200	46.50	0.86
150	52.12	0.97	1500	45.50	0.84
180	52.00	0.96	1800	45.25	0.84
210	51.62	0.96	2100	44.75	0.83
240	51.25	0.95	2400	43.50	0.81
270	51.12	0.95	2700	42.87	0.79
300	50.87	0.94	3000	42.75	0.79
*360	50.5	0.94	3300	42.12	0.78
420	50.12	0.93	3600	42.12	0.78
480	49.75	0.92			
540	49.50	0.92			
600	48.87	0.91			
660	48.75	0.90			



TIME (T) SECONDS

DRAWDOWN CURVE

H/Ho vs TIME

WELL S 86 (50-52')

NUS CORPORATION

PERMEABILITY FROM GRAIN SIZE ANALYSIS*

Borehole	Depth (feet)	Particle** Size D_{10} (cm)	Permeability (cm/sec)	Sample description	Remarks
S-63	13	1.5×10^{-3}	2.25×10^{-4}	Brown sand, little gravel, trace silt	Low
S-64M	9	9.0×10^{-5}	8.1×10^{-7}	Brown sand, little gravel, trace silt	Very Low
S-64M	32	8.0×10^{-5}	6.4×10^{-7}	Brown silty sand, little clay and gravel	Very Low
S-66D	10	7.0×10^{-5}	4.9×10^{-7}	Brown silty sand, little clay	Very Low
S-67	15	8.5×10^{-5}	7.22×10^{-7}	Brown silty sand, little clay and gravel	Very Low
S-67	40	7.5×10^{-4}	5.62×10^{-5}	Brown and gray sand, little silt, trace gravel	Low
S-70	15	6.0×10^{-4}	3.6×10^{-5}	Brown and gray silty sand, some gravel, trace clay	Low
S-70D	35	5.0×10^{-5}	2.5×10^{-7}	Gray silty sand, some gravel, little clay	Very Low
S-70D	55	1.5×10^{-3}	2.25×10^{-4}	Brown sand, little gravel, trace silt and clay	Low
S-71	0	7.0×10^{-4}	4.9×10^{-5}	Black gravel, some sand, little silt	Low
S-71	2	8.0×10^{-4}	6.4×10^{-5}	Gray gravel and sand, little silt	Low
S-71	4	8.5×10^{-4}	7.22×10^{-5}	Gray sand, some gravel, little silt	Low

* Lambe & Whitman, Soil Mechanics p. 290

** D_{10} = the particle size where only 10 percent of sample is finer.

PERMEABILITY FROM GRAIN SIZE ANALYSIS* PAGE TWO

Borehole	Depth (feet)	Particle** Size D_{10} (cm)	Permeability (cm/sec)	Sample description	Remarks
S-71	6	3.0×10^{-4}	9.0×10^{-6}	Gray silty sand, some gravel, trace clay	Very Low
S-71	8	2.3×10^{-4}	5.29×10^{-6}	Gray sand, some gravel and silt	Very Low
S-71	10	6.0×10^{-4}	3.6×10^{-5}	Brown gravel, some sand, little silt	Low
S-71	12	6.0×10^{-4}	3.6×10^{-5}	Gray silty sand, some gravel, little silt	Low
S-71	14	2.3×10^{-3}	5.29×10^{-4}	Brown gravel and sand, trace silt	Low
S-72D	35	1.5×10^{-4}	2.25×10^{-6}	Gray and brown mottled sandy silt trace clay	Very Low
S-72D	55	1.3×10^{-4}	1.69×10^{-6}	Gray and brown mottled sandy silt, trace clay	Very Low
S-72D	80	1.5×10^{-3}	2.25×10^{-4}	Gray sand, trace silt	Low
S-74M	39	7.0×10^{-4}	4.9×10^{-5}	Brown sand, little silt	Low
S-74M	34	1.5×10^{-4}	2.25×10^{-6}	Brown silty sand, trace clay	Very Low
S-75D	10	2.0×10^{-3}	4.0×10^{-4}	Brown sand, little gravel, trace silt	Low
S-75D	40	6.0×10^{-4}	3.6×10^{-5}	Gray silty sand, trace clay	Low
S-75D	65	2.0×10^{-4}	4.0×10^{-6}	Gray and brown mottled sandy silt, trace clay	Very Low

* Lambe & Whitman, Soil Mechanics p. 290

** D_{10} = the particle size where only 10 percent of sample is finer.

PERMEABILITY FROM GRAIN SIZE ANALYSIS* PAGE THREE

Borehole	Depth (feet)	Particle** Size D_{10} (cm)	Permeability (cm/sec)	Sample description	Remarks
S-76	21	1.8×10^{-4}	3.24×10^{-6}	Brown silty sand, trace clay	Very Low
S-76M	60	4.5×10^{-4}	2.02×10^{-5}	Brown silty sand, trace clay	Low
S-77	20	1.5×10^{-3}	2.25×10^{-4}	Brown sand trace gravel	Low
S-77D	70	2.2×10^{-3}	4.84×10^{-4}	Brown sand, trace gravel	Low
S-77D	120	3.2×10^{-5}	1.02×10^{-7}	Brown and gray mottled sandy silt, some clay, little sand	Very Low
S-78	17	8.0×10^{-4}	6.4×10^{-5}	Brown sand trace gravel	Low
S-78	63	3.5×10^{-5}	1.22×10^{-7}	Brown and gray silty sand, little clay	Very Low
S-79	14	1.7×10^{-3}	2.89×10^{-4}	Brown sand, trace silt	Low
S-79	69	6.5×10^{-4}	4.22×10^{-5}	Brown sand, little gravel and silt	Low
S-80	8	1.5×10^{-4}	2.25×10^{-6}	Gray silty sand, trace clay	Very Low
S-80	-	7.0×10^{-4}	4.9×10^{-5}	Brown sand, some gravel, little silt, trace clay	Low
S-82	10	5.0×10^{-4}	2.5×10^{-5}	Brown and gray silty sand, some gravel, trace clay	Low
S-82	20	7.5×10^{-4}	5.62×10^{-5}	Brown sand, little silt, trace gravel	Low

* Lambe & Whitman, Soil Mechanics p. 290

** D_{10} = the particle size where only 10 percent of sample is finer.

PERMEABILITY FROM GRAIN SIZE ANALYSIS* PAGE FOUR

Borehole	Depth (feet)	Particle** Size D_{10} (cm)	Permeability (cm/sec)	Sample description	Remarks
S-82	35	4.0×10^{-5}	1.6×10^{-7}	Brown silty sand, some gravel, little clay	Very Low
S-83	40	1.7×10^{-3}	2.89×10^{-4}	Brown sand, some gravel, trace silt	Low
S-83	60	2.5×10^{-3}	6.25×10^{-4}	Brown sand, trace gravel	Low
S-83	80	3.0×10^{-4}	9.0×10^{-6}	Brown silty sand, little gravel, trace clay	Very Low
S-84	10	2.5×10^{-3}	6.25×10^{-4}	Brown sand, some gravel	Low
S-84	40	1.5×10^{-3}	2.25×10^{-4}	Brown sand, some gravel, trace silt	Low
S-84	65	1.0×10^{-3}	1.0×10^{-4}	Brown gravel and sand, trace silt	Low
S-85	34	2.8×10^{-3}	7.84×10^{-4}	Brown sand, some gravel	Low
S-85	59	2.2×10^{-4}	4.84×10^{-6}	Brown and gray silty sand, some gravel, trace clay	Very Low
S-86D	25	2.0×10^{-3}	4.0×10^{-4}	Brown gravel and sand	Low
S-86D	50	2.3×10^{-3}	5.29×10^{-4}	Brown sand, trace gravel and silt	Low

* Lambe & Whitman, Soil Mechanics p. 290

** D_{10} = the particle size where only 10 percent of sample is finer.

MOISTURE AND GRADATION ANALYSIS

Gradation

Percentage Retained on Standard Sieve

BORING NUMBER	SAMPLE NUMBER	DEPTH (FT.)	MOISTURE (%)	3/4	4	10	20	40	60	140	200	SILT (%)	CLAY (%)	SOIL CLASS
S63	1	13	7.5	11.4	10.9	12.2	15.5	13.1	10.0	22.7	0.6	**	3.6	SP
S64M	2	9	16.1	0.0	0.8	3.2	10.1	18.4	23.2	17.0	1.5	20.0	5.8	SM
S64M	3	32	13.4	3.9	12.9	4.7	6.6	7.3	9.8	28.4	0.8	17.4	8.2	SM
S66D	5	10	7.5	0.0	12.6	6.0	8.9	12.0	10.0	16.3	4.6	21.2	8.4	SM
S67	6	15	9.1	10.1	12.3	7.9	8.9	10.5	9.5	13.7	3.1	17.1	6.9	SM
S67	7	40	18.3	0.0	0.1	0.1	0.3	2.0	28.0	54.0	5.5	8.9	1.1	SP-SM
70	8	15	4.3	5.0	24.6	15.8	15.3	10.3	6.7	8.1	1.2	9.3	3.7	SM
70D	9	35	5.0	19.7	6.9	7.2	8.1	8.4	17.1	1.1	2.1	19.5	9.9	SM
70D	10	55	10.9	9.2	10.7	13.1	16.6	17.7	13.2	11.4	1.7	5.3	1.1	SP-SM
Unifirst	11	0	7.6	21.1	45.2	5.4	4.7	3.3	2.6	4.4	1.4	10.8	1.1	GM
Unifirst	12	2	1.6	17.1	29.0	12.4	10.5	8.1	5.4	5.6	2.1	8.8	1.0	GP-GM
Unifirst	13	4	0.7	0.0	42.2	3.7	12.8	8.9	9.6	9.6	5.2	7.0	1.0	SP-SM
Unifirst	14	6	3.3	13.8	24.7	10.6	9.5	7.4	5.8	8.8	1.9	12.4	5.1	SM
Unifirst	15	8	2.5	25.1	12.8	7.5	8.0	7.5	6.5	10.1	2.2	14.9	5.4	SM

** Hydrometer Analysis Not Performed

MOISTURE AND GRADATION ANALYSIS

Gradation

Percentage Retained on Standard Sieve

BORING NUMBER	SAMPLE NUMBER	DEPTH (FT.)	MOISTURE (%)	3/4	4	10	20	40	60	140	200	SILT (%)	CLAY (%)	SOIL CLASS
Unifirst	16	10	0.8	32.0	18.3	4.7	6.7	6.7	5.6	9.3	2.8	12.6	1.3	GM
Unifirst	17	12	0.8	0.0	31.0	5.3	7.7	10.3	10.6	19.2	0.5	14.2	1.2	SM
Unifirst	18	14	5.1	24.2	31.5	9.5	8.5	8.3	6.8	9.4	1.6	**	0.2	GP
S72R	19	35	19.9	0.0	0.0	0.0	0.0	0.2	1.0	40.2	3.2	51.0	4.4	ML
S72R	20	55	19.7	0.0	0.2	0.5	0.5	0.3	0.2	40.0	1.2	52.6	4.5	ML
S72R	21	80	14.9	0.0	0.0	0.5	17.3	39.0	23.0	12.5	1.7	5.0	1.0	SP
S74M	22	39	19.6	0.0	0.0	0.1	0.0	37.7	27.4	20.8	2.8	10.2	1.0	SP
S74M	23	34	17.8	0.0	0.0	0.1	2.2	6.4	11.5	28.7	4.4	42.5	4.2	SM
S75D	24	10	6.7	0.0	13.9	12.0	26.5	24.9	10.0	7.3	0.5	**	4.9	SP
S75D	25	40	20.9	0.0	0.4	2.6	10.0	22.7	44.5	2.6	2.3	13.9	1.0	SM
S75D	26	65	19.2	0.0	0.0	0.1	0.7	2.3	3.3	8.0	1.8	77.2	6.6	ML
S76	27	21	19.8	0.0	0.0	0.0	0.0	0.3	0.6	57.5	2.8	35.5	3.3	SM
S76M	28	60	21.3	0.0	0.0	0.0	0.0	0.3	10.0	61.8	9.3	17.4	1.2	SM
S77	29	20	19.0	0.0	0.3	0.3	0.2	1.3	19.5	70.7	4.5	**	3.2	SP

** Hydrometer Analysis Not Performed

MOISTURE AND GRADATION ANALYSIS

Gradation

Percentage Retained on Standard Sieve

BORING NUMBER	SAMPLE NUMBER	DEPTH (FT.)	MOISTURE (%)	3/4	4	10	20	40	60	140	200	SILT (%)	CLAY (%)	SOIL CLASS
S77D	30	70	14.3	0.0	0.1	5.3	22.5	36.0	23.1	8.4	0.6	**	4.0	SP
S77D	31	120	17.3	0.0	0.0	0.0	0.0	0.0	0.1	4.7	3.2	78.0	14.0	ML
S78	32	17	19.0	0.0	0.5	1.6	1.9	2.8	17.4	59.7	7.2	**	8.9	SP
S78	33	63	20.4	0.0	0.0	0.0	0.1	0.2	4.6	48.7	5.9	28.4	12.1	SM
S79	34	14	20.1	0.0	0.0	0.5	1.5	7.1	30.2	57.3	1.4	**	2.0	SP
S79	35	69	15.7	0.0	16.4	14.9	11.4	6.4	3.9	33.8	1.4	10.6	1.2	SP-SM
S80	36	8	24.8	0.0	0.0	0.3	0.9	1.1	4.2	50.6	2.2	36.7	4.0	SM
S80	37	--	5.0	9.8	11.6	4.3	10.5	14.1	14.9	20.9	3.1	9.5	1.3	SP-SM
S82	38	10	12.3	0.0	22.3	9.4	9.8	10.1	8.6	21.3	2.7	14.7	1.1	SM
S82	39	20	18.9	0.0	1.3	0.9	1.4	5.8	24.9	54.0	1.3	9.4	1.0	SP-SM
S82	40	35	8.9	0.0	18.5	5.9	7.9	8.7	9.1	18.5	2.7	17.7	11.0	SM
S83	41	40	11.2	14.1	5.6	5.8	15.3	16.3	15.7	21.1	0.9	**	5.2	SP-SM
S83	42	60	12.7	3.6	4.0	13.3	27.1	26.2	16.8	2.1	0.7	**	6.2	SP-SM
S83	43	80	14.9	6.1	7.5	0.4	3.5	4.7	2.1	47.1	1.0	25.6	2.0	SM

** Hydrometer Analysis Not Performed

MOISTURE AND GRADATION ANALYSIS

Gradation

Percentage Retained on Standard Sieve

BORING NUMBER	SAMPLE NUMBER	DEPTH (FT.)	MOISTURE (%)	3/4	4	10	20	40	60	140	200	SILT (%)	CLAY (%)	SOIL CLASS
S84	44	10	8.4	12.3	29.7	16.3	17.8	9.4	4.7	5.2	0.8	**	3.8	SP
S84	45	40	9.0	15.4	17.6	5.2	10.7	17.2	13.8	11.7	1.1	6.3	1.0	SP-SM
S84	46	65	6.0	13.5	38.5	14.3	6.7	3.3	3.8	8.6	1.6	8.2	1.5	GP-GM
S85	47	34	10.1	15.8	26.0	11.1	14.1	14.9	10.5	4.1	0.4	**	3.1	SP
S85	48	59	7.7	10.3	21.1	12.2	9.5	5.8	5.1	11.1	2.4	17.5	5.0	SM
S86D	49	25	4.5	24.7	31.4	10.3	10.0	6.7	4.4	6.1	1.3	**	5.1	GP-GM
S86D	50	50	18.2	0.0	2.8	0.1	0.2	2.4	38.2	50.2	2.0	**	4.1	SP

** Hydrometer Analysis Not Performed