BP OIL

BP Oil Company
Environmental Resources Management
Building 13, Suite N
295 SW 41st Street
Renton, Washington 98055-4931
(206) 251-0667

ENVIRONMENTAL
PROTECTION

95 AUG 31 AM 11:04

August 29, 1995

Alameda County Health Care Services Agency
Attention Mr. Scott Seery
1131 Harbor Bay Parkway, Room 250
Alameda, CA 94502-6577

RE: BP Oil Site No. 11105
3515 Castro Valley Boulevard
Castro Valley, CA

Dear Mr. Seery:

Enclosed please find a report titled Groundwater Monitoring and Sampling Report, dated June 30, 1995. Let me know if you have questions regarding this report.

As you are aware, the fieldwork for supplemental investigation was implemented during late July. Alisto Engineering Group is in the process of writing the report, and I will forward a copy to you upon receipt. I expect that this will occur sometime within the next eight weeks. If this reporting schedule presents any concerns, let me know.

Also enclosed is the MW-5 baildown test data, graph, calculations along with relevant text copied from a textbook titled Groundwater by R. A. Freeze and J. A. Cherry (1979). I have also enclosed some additional copies of semi-logarithm paper in the event that you have not yet had the chance to reduce the data and calculate the hydraulic conductivity of the material screened by MW-5. Based on the data we collected, we calculated a hydraulic conductivity of 0.0000263 cm/sec. This measurement falls in the middle of the range of silt or loess[1], the upper range of a glacial till, or the lower range of a silty sand. The silt range seems most consistent with the material described for the screened interval on the MW-5[2] Boring Log and Well Completion Summary (also enclosed).

As you will recall, we performed the baildown test to assist in determining whether groundwater at this site is confined or unconfined. I am reluctant to address this question at length here, because we can more likely address this efficiently and productively by discussing the matter in person. Before we do, however, I ask that you further consider how groundwater is released from storage under confined and unconfined conditions[3].

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[1] Wind-blown blanket deposits of silt common in the Midwest and Great Plains regions of North America. Perhaps this should go without saying, but loess should not be expected to be present in significant quantities in the San Francisco Bay Area.

[2] Clay Silt, Sandy Silt, Clay Silt with increasing sand content

[3] Water stored in unconfined aquifers is produced by gravity drainage; water stored in confined aquifers is supplied by the compression of the skeletal material in the aquifer matrix and the expansion of the water. So

Please give me a call if you have any questions or comments regarding this information. I can be reached at (206) 251-0689.

Sincerely,

Scott Hooton
Environmental Resources Management

attachments

cc: site file
B. Nagle - AEG (Baildown data only)
CRWQCB-SFBR, Attention Mr. E. So, 2101 Webster Street, Ste.500, Oakland, CA 94612 (w/ all attachments)

---

it follows that the storage coefficient for a confined aquifer is much lower than would occur in an unconfined aquifer.

white -env.health
yellow -facility
pink -files

ALAMEDA COUNTY, DEPARTMENT OF ENVIRONMENTAL HEALTH

1131 Harbor Bay Pkwy
Alameda CA 94502
510/567-6700

Hazardous Materials Inspection Form

II, III

Site ID # ______ Site Name BP Oil Today's Date 7/19/95

Site Address 3519 Castro Valley Blvd

City Castro Valley Zip 94546 Phone ______

_____ MAX AMT stored > 500 lbs, 55 gal., 200 cft.?

Inspection Categories:

_____ I. Haz. Mat/Waste GENERATOR/TRANSPORTER
_____ II. Hazardous Materials Business Plan, Acutely Hazardous Materials
_____ III. Underground Storage Tanks

* Calif. Administration Code (CAC) or the Health & Safety Code (HS&C)

Comments: WELL MW-5 recovery test

2:15 initial DTW = 8.09

		DTW		
Start time:	2:25.55			DTW
T=0	2:26.24	12.70	2:36.57	10.8
T=19	2:26.43	12.6	2:37.56	10.7
	2:27.04	12.5	2:38.54	10.6
	2:27.26	12.4	2:39.55	10.5
	2:27.48	12.3	2:40.59	10.4
	2:28.13	12.2	2:42 07	10.3
	2:28.40	12.1	2:43.25	10.2
	2:29.08	12.0	2:44.44	10.1
	2:29.36	11.9	2:46.14	10.0
	2:30.07	11.8	2:51.26	9.7
	2:30.38	11.7	3:00.32	9.3
	2:31.14	11.6	3:12.04	8.8
	2:31.49	11.5	2:20.41	8.5
	2:32.28	11.4	[illegible]	[illegible]
	2:33.08	11.3	[illegible]	[illegible]
	2:33.50	11.2		
	2:34.33	11.1		
	2:35.18	11.0		
	2:36.08	10.9		

11105

II, III

Contact ______
Title ______ Inspector ______
Signature ______ Signature ______

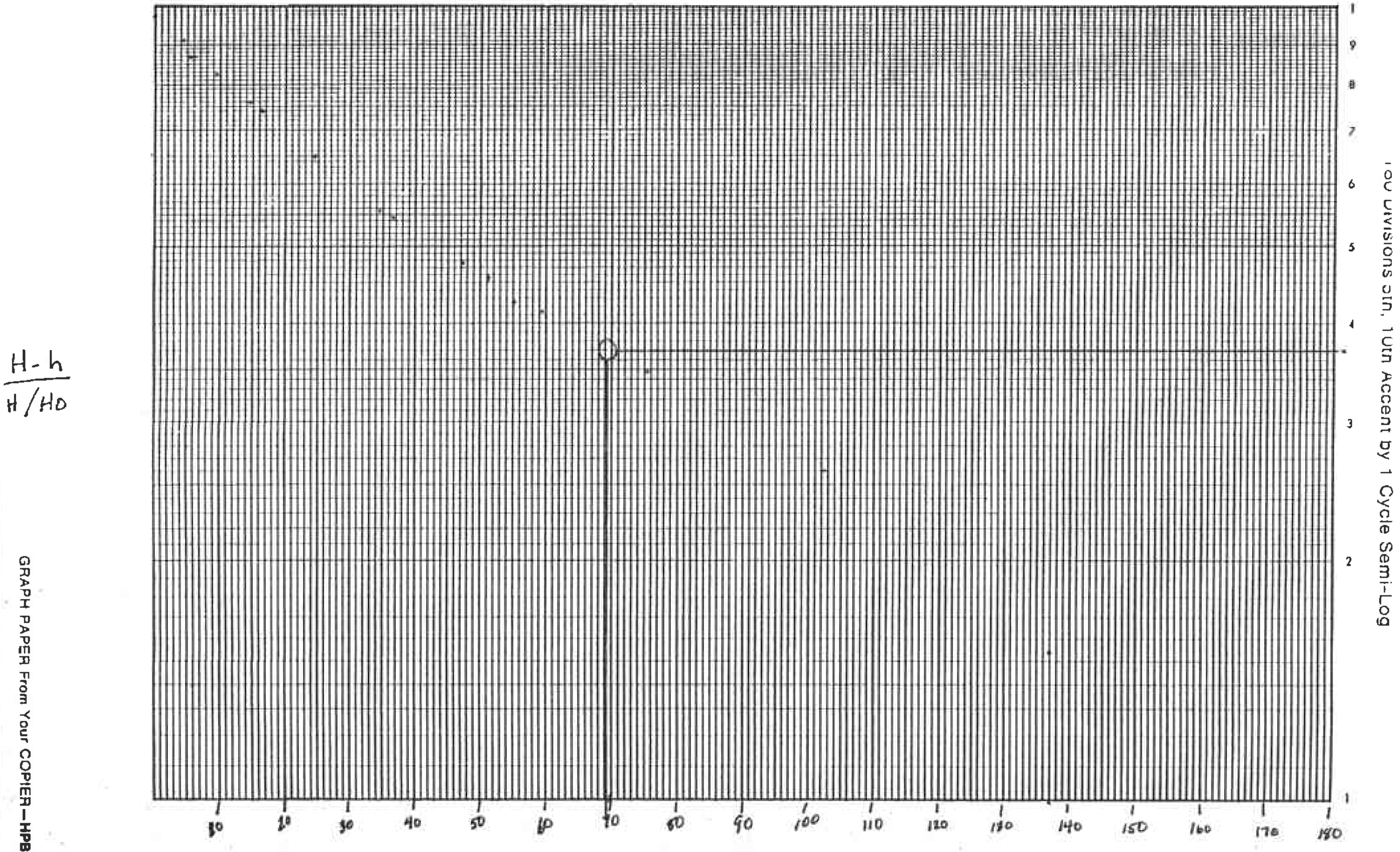
unrecovered Headspace

MW-5 / Site 11105
7/19/95
Recovery test Data

Time in seconds		DTW	H-h	H/HO	H-h/H/HO	
2:26:24	T=0	12.70	4.610	4.610	1.000	✗
2:26:43	T=19	12.60	4.510	4.610	0.978	✓
2:27:04	T=40	12.50	4.410	4.610	0.957	
2:27:26	T=62	12.40	4.310	4.610	0.935	
2:27:48	T=84	12.30	4.210	4.610	0.913	✓4.20
2:28:13	T=109	12.20	4.110	4.610	0.892	
2:28:40	T=136	12.10	4.010	4.610	0.870	✓ 6.80
2:29:08	T=164	12.00	3.910	4.610	0.848	✓ 9.60
2:29:36	T=192	11.90	3.810	4.610	0.826	
2:30:07	T=223	11.80	3.710	4.610	0.805	
2:30:38	T=254	11.70	3.610	4.610	0.783	
2:31:14	T=290	11.60	3.510	4.610	0.761	✓ 14.50
2:31:49	T=325	11.50	3.410	4.610	0.740	✓ 16.25
2:32:28	T=364	11.40	3.310	4.610	0.718	
2:33:08	T=404	11.30	3.210	4.610	0.696	
2:33:50	T=446	11.20	3.110	4.610	0.675	
2:34:33	T=489	11.10	3.010	4.610	0.653	✓ 24.45
2:35:18	T=534	11.00	2.910	4.610	0.631	
2:36:08	T=584	10.90	2.810	4.610	0.610	
2:36:57	T=633	10.80	2.710	4.610	0.588	
2:37:56	T=692	10.70	2.610	4.610	0.566	✓ 34.60
2:38:54	T=750	10.60	2.510	4.610	0.544	✓ 37.5
2:39:55	T=811	10.50	2.410	4.610	0.523	
2:40:59	T=875	10.40	2.310	4.610	0.501	
2:42:07	T=943	10.30	2.210	4.610	0.479	✓ 47.15
2:43:25	T=1021	10.20	2.110	4.610	0.458	✓ 51.05
2:44:44	T=1100	10.10	2.010	4.610	0.436	✓ 55
2:46:14	T=1190	10.00	1.910	4.610	0.414	✓ 59.50
2:51:26	T=1502	9.70	1.610	4.610	0.349	✓ 75.10
3:00:32	T=2048	9.30	1.210	4.610	0.262	✓ 102.40
3:12:04	T=2740	8.80	0.710	4.610	0.154	✓ 137
3:20:41	T=3257	8.50	0.410	4.610	0.089	✗

Each space = 20 sec

Site 11105
MW-5
7/19/95
Recovery test Data



$t_{.37}$ = 1390 sec

(time * 20 seconds)

11105

7/19/55 Recovery test
Hvorslev Method

FROM Freeze & Cherry, pg 341, Equation 8-34

$$K = \frac{r^2 \ln\left(L/R\right)}{2 L T_0}$$

$$= \frac{(2.54\ \text{cm})^2 \ln\left(\frac{457.2\ \cancel{\text{cm}}}{2.54\ \cancel{\text{cm}}}\right)}{(2)(457.2\ \text{cm})(1390\ \text{sec.})}$$

$$= \frac{6.452\ \text{cm}^{\cancel{2}} \ln 180}{1{,}271{,}016\ \cancel{\text{cm}} \cdot \text{sec}}$$

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

FROM FREEZE & Cherry, pg 29

$K = 2.63 \times 10^{-5}$ cm/sec – Falls into the K range of:

- "more permeable" Glacial till
- "less permeable" Silty Sand
- "center range" of a Silt or loess

Environmental Science & Engineering, Inc.
A CILCORP Company

BORING LOG AND WELL COMPLETION SUMMARY

MW-5

Page 1 of 1

WELL COMPLETION

Completion Depth: 24 Feet

	Size/Type	From	To
Casing:	2" Diam. Sched. 40 PVC	9 Feet	0 Feet
Screen:	2" Diam. Sched. 40 Slotted (0.02") PVC	24 Feet	9 Feet
Filter:	#3 Sand	24 Feet	8 Feet
Seal:	Bentonite	8 Feet	5.5 Feet
	Grout	5.5 Feet	0 Feet

Well Cap or Box: Flush Mounted Well Box

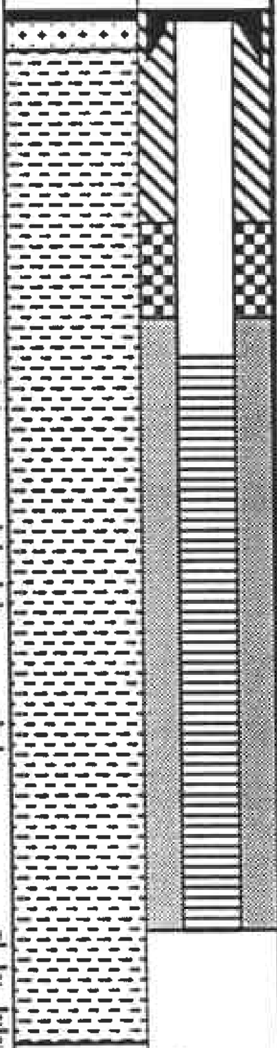
Project Name: BP Oil Company
Project No: 6-92-5428
Location: BP Station #11105
3519 Castro Valley Boulevard
Castro Valley, CA

Driller: Soils Exploration Services, Inc.
Method: HSA
Hole Diameter: 8"
Total Depth: 27 Feet
Ref. Elevations:
Logged By: Chris Valcheff

Dates:
Start: 9-28-92
Finish: 9-28-92

Depth (ft)	Lithologic Description	USC	Sample/Blows	Vapor	Remarks Water, drilling/completion, summary, sample type
0	Asphalt FILL GRAVEL, cement fragment at 0.7 feet with hydrocarbon staining.	GP			
	NATIVE CLAY SILT, black-grey, 20-30% medium to coase grained sand, stiff, damp, slight hydrocarbon odor.				
5	CLAY SILT, olive with blue-grey mottling, 25-30% fine to coarse grained sand, stiff, damp, slight hydrocarbon odor.		3 4 5	40	SAMPLE @ 5 FEET
	▽ water @ 6.55' on 7/1/98 at 1415 hrs				
	CLAY SILT, olive, decrease in sand content, stiff, damp, slight hydrocarbon odor.		5 6 11	175	SAMPLE @ 10 FEET
10	CLAY SILT, olive with blue-grey mottle, 80-90% silt and clay, stiff, damp.	ML			
	SANDY SILT, orange-brown with minor mottling, 30-40% fine to coarse grained sand, stiff, damp.		7 12 12	8.5	SAMPLE @ 14 FEET
15	CLAY SILT, light brown, stiff, damp, no odor.		6 9 12		STANDARD PEN.
					▽ Ground Water @ 18 Feet
	As above, wet, slight increase in sand content.		8 10 10		
20					
	As above, orange-brown, dry.		10 21 22		
25	As above, damp.		8 12 12		TOTAL DRILLED DEPTH = 24 FEET TOTAL DEPTH = 27 FEET
30					

Graphic Log



REGISTERED GEOLOGIST
SUSAN B. WICKHAM
#3851
STATE OF CALIFORNIA

GROUNDWATER

R. Allan Freeze/John A. Cherry

consolidation, c_v, which is defined as

$$c_v = \frac{K}{\rho g \alpha} \tag{8.30}$$

At each loading level in a consolidation test, the sample undergoes a transient drainage process (fast for sands, slow for clays) that controls the rate of consolidation of the sample. If the rate of decline in sample thickness is recorded for each loading increment, such measurements can be used in the manner described by Lambe (1951) to determine the coefficient of consolidation, c_v, and the hydraulic conductivity, K, of the soil.

In Section 8.12, we will further examine the mechanism of one-dimensional consolidation in connection with the analysis of land subsidence.

Unsaturated Characteristic Curves

The characteristic curves, $K(\psi)$ and $\theta(\psi)$, that relate the moisture content, θ, and the hydraulic conductivity, K, to the pressure head, ψ, in unsaturated soils were described in Section 2.6. Figure 2.13 provided a visual example of the hysteretic relationships that are commonly observed. The methods used for the laboratory determination of these curves have been developed exclusively by soil scientists. It is not within the scope of this text to outline the wide variety of sophisticated laboratory instrumentation that is available. Rather, the reader is directed to the soil science literature, in particular to the review articles by L. A. Richards (1965), Klute (1965b), Klute (1965c), and Bouwer and Jackson (1974).

8.5 Measurement of Parameters: Piezometer Tests

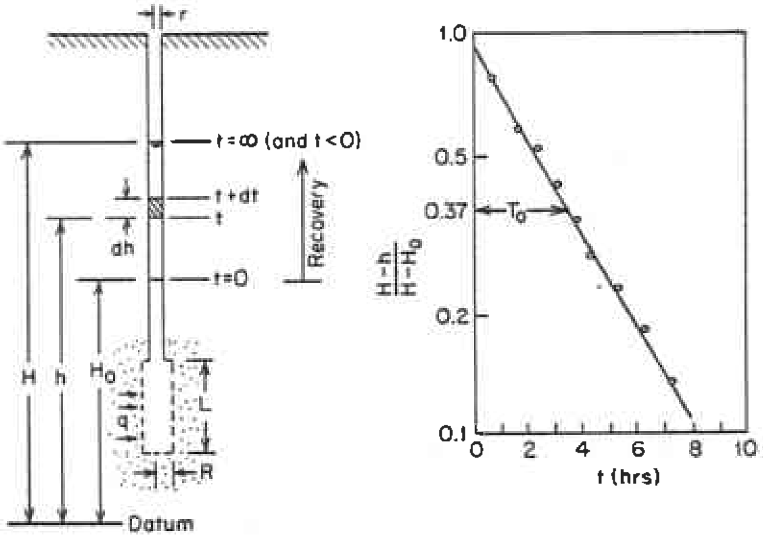
It is possible to determine *in situ* hydraulic conductivity values by means of tests carried out in a single piezometer. We will look at two such tests, one suitable for point piezometers that are open only over a short interval at their base, and one suitable for screened or slotted piezometers that are open over the entire thickness of a confined aquifer. Both tests are initiated by causing an instantaneous change in the water level in a piezometer through a sudden introduction or removal of a known volume of water. The recovery of the water level with time is then observed. When water is removed, the tests are often called *bail tests*; when it is added, they are known as *slug tests*. It is also possible to create the same effect by suddenly introducing or removing a solid cylinder of known volume.

The method of interpreting the water level versus time data that arise from bail tests or slug tests depends on which of the two test configurations is felt to be most representative. The method of Hvorslev (1951) is for a point piezometer, while that of Cooper et al. (1967) is for a confined aquifer. We will now describe each in turn.

The simplest interpretation of piezometer-recovery data is that of Hvorslev (1951). His initial analysis assumed a homogeneous, isotropic, infinite medium in which both soil and water are incompressible. With reference to the bail test of Figure 8.20(a), Hvorslev reasoned that the rate of inflow, q, at the piezometer tip at any time t is proportional to the hydraulic conductivity, K, of the soil and to the unrecovered head difference, $H - h$, so that

$$q(t) = \pi r^2 \frac{dh}{dt} = FK(H - h) \tag{8.31}$$

where F is a factor that depends on the shape and dimensions of the piezometer intake. If $q = q_0$ at $t = 0$, it is clear that $q(t)$ will decrease asymptotically toward zero as time goes on.



(a) (b)

Figure 8.20 Hvorslev piezometer test. (a) Geometry; (b) method of analysis.

Hvorslev defined the *basic time lag*, T_0, as

$$T_0 = \frac{\pi r^2}{FK} \tag{8.32}$$

When this parameter is substituted in Eq. (8.31), the solution to the resulting ordinary differential equation, with the initial condition, $h = H_0$ at $t = 0$, is

$$\frac{H - h}{H - H_0} = e^{-t/T_0} \tag{8.33}$$

A plot of field recovery data, $H - h$ versus t, should therefore show an exponential decline in recovery rate with time. If, as shown on Figure 8.20(b), the recovery is normalized to $H - H_0$ and plotted on a logarithmic scale, a straight-line plot results. Note that for $H - h/H - H_0 = 0.37$, $\ln (H - h/H - H_0) = -1$, and from Eq. (8.33), $T_0 = t$. The basic time lag, T_0, can be defined by this relation; or if a more physical definition is desired, it can be seen, by multiplying both top and bottom of Eq. (8.32) by $H - H_0$, that T_0 is the time that would be required for the complete equalization of the head difference if the original rate of inflow were maintained. That is, $T_0 = V/q_0$, where V is the volume of water removed or added.

To interpret a set of field recovery data, the data are plotted in the form of Figure 8.20(b). The value of T_0 is measured graphically, and K is determined from Eq. (8.32). For a piezometer intake of length L and radius R [Figure 8.20(a)], with $L/R > 8$, Hvorslev (1951) has evaluated the shape factor, F. The resulting expression for K is

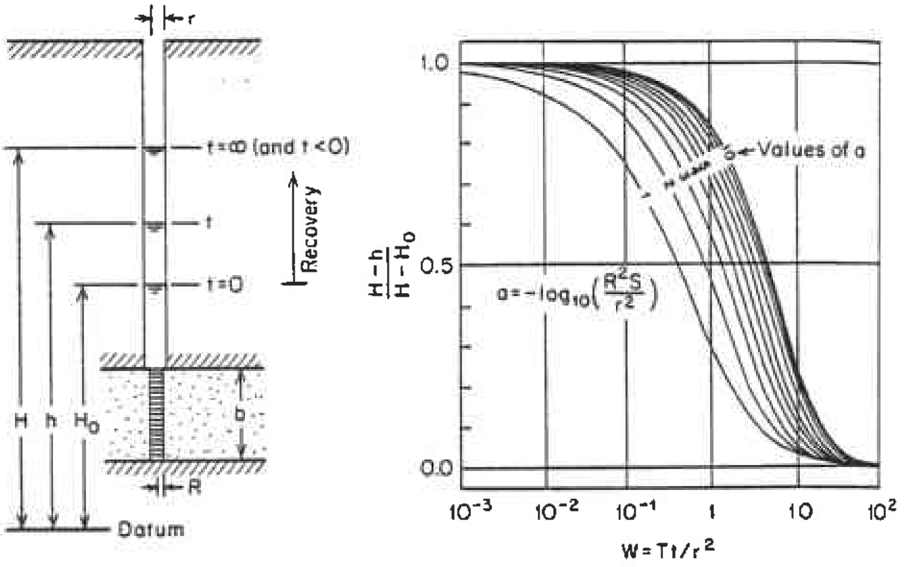
$$K = \frac{r^2 \ln (L/R)}{2LT_0} \tag{8.34}$$

Hvorslev also presents formulas for anisotropic conditions and for a wide variety of shape factors that treat such cases as a piezometer open only at its basal cross section and a piezometer that just encounters a permeable formation underlying an impermeable one. Cedergren (1967) also lists these formulas.

In the field or agricultural hydrology, several *in situ* techniques, similar in principle to the Hvorslev method but differing in detail, have been developed for the measurement of saturated hydraulic conductivity. Boersma (1965) and Bouwer and Jackson (1974) review those methods that involve auger holes and piezometers.

For bail tests of slug tests run in piezometers that are open over the entire thickness of a confined aquifer, Cooper et al. (1967) and Papadopoulos et al. (1973) have evolved a test-interpretation procedure. Their analysis is subject to the same assumptions as the Theis solution for pumpage from a confined aquifer. Contrary to the Hvorslev method of analysis, it includes consideration of both formation and water compressibilities. It utilizes a curve-matching procedure to determine the aquifer coefficients T and S. The hydraulic conductivity K can then be determined on the basis of the relation, $K = T/b$. Like the Theis solution, the method is based on the solution to a boundary-value problem that involves the transient equation of groundwater flow, Eq. (2.77). The mathematics will not be described here.

For the bail-test geometry shown in Figure 8.21(a), the method involves the preparation of a plot of recovery data in the form $H - h/H - H_0$ versus t. The plot is prepared on semilogarithmic paper with the reverse format to that of the Hvorslev test; the $H - h/H - H_0$ scale is linear, while the t scale is logarithmic. The field curve is then superimposed on the type curves shown in Figure 8.21(b). With the axes coincident, the data plot is translated horizontally into a position where the data best fit one of the type curves. A matchpoint is chosen (or rather, a vertical axis is matched) and values of t and W are read off the horizontal scales



(a) (b)

Figure 8.21 Piezometer test in a confined aquifer. (a) Geometry; (b) type curves (after Papadopoulos et al., 1973).

at the matched axis of the field plot and the type plot, respectively. For ease of calculation it is common to choose a matched axis at $W = 1.0$. The transmissivity T is then given by

$$T = \frac{Wr^2}{t} \tag{8.35}$$

where the parameters are expressed in any consistent set of units.

In principle, the storativity, S, can be determined from the a value of the matched curve and the expression shown on Figure 8.21(b). In practice, since the slopes of the various a lines are very similar, the determination of S by this method is unreliable.

The main limitation on slug tests and bail tests is that they are heavily dependent on a high-quality piezometer intake. If the wellpoint or screen is corroded or clogged, measured values may be highly inaccurate. On the other hand, if a piezometer is developed by surging or backwashing prior to testing, the measured values may reflect the increased conductivities in the artificially induced gravel pack around the intake.

It is also possible to determine hydraulic conductivity in a piezometer or single well by the introduction of a tracer into the well bore. The tracer concentration decreases with time under the influence of the natural hydraulic gradient that exists in the vicinity of the well. This approach is known as the *borehole dilution method*, and it is described more fully in Section 9.4.

e flow systems makes the use of a fluid-free conductance
n measured in m² or cm². k is very small, so petroleum
darcy as a unit of permeability. If Eq. (2.28) is substituted
ecomes

$$v = \frac{-k\rho g}{\mu}\frac{dh}{dl} \qquad (2.29)$$

, 1 darcy is defined as the permeability that will lead to
n/s for a fluid with a viscosity of 1 cp under a hydraulic
erm $\rho g\, dh/dl$ equal to 1 atm/cm. One darcy is approxi-

lustry, the unit gal/day ft² is widely used for hydraulic
: is clearest when Darcy's law is couched in terms of Eq.

$$Q = -K\frac{dh}{dl}A$$

vided by the U.S. Geological Survey with regard to this
a laboratory coefficient and a field coefficient. However,
e definitions (Lohman, 1972) has discarded this formal
ent to note that differences in the temperature of measure-
vironment and the laboratory environment can influence
lues through the viscosity term in Eq. (2.28). The effect is
ion factors are seldom introduced. It still makes good
hydraulic conductivity measurements have been carried
n the field, because the methods of measurement are very
etations placed on the values may be dependent on the
owever, this information is of practical rather than con-

he range of values of hydraulic conductivity and perme-
ystems of units for a wide range of geological materials.
rt on the data summarized in Davis' (1969) review. The
can be drawn from the data is that hydraulic conductivity
ange. There are very few physical parameters that take on
magnitude. In practical terms, this property implies that
knowledge of hydraulic conductivity can be very useful.
cimal place in a reported conductivity value probably has

a set of conversion factors for the various common units
le of its use, note that a k value in cm² can be converted to
g by 1.08×10^{-3}. For the reverse conversion from ft² to
10^3.

Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

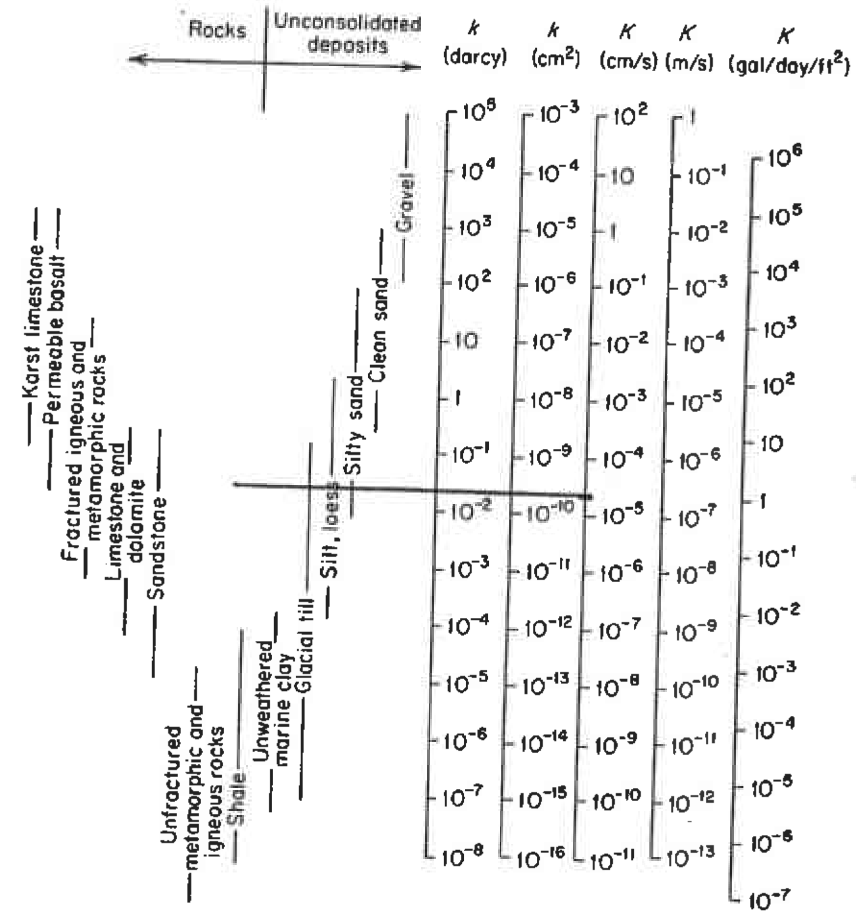
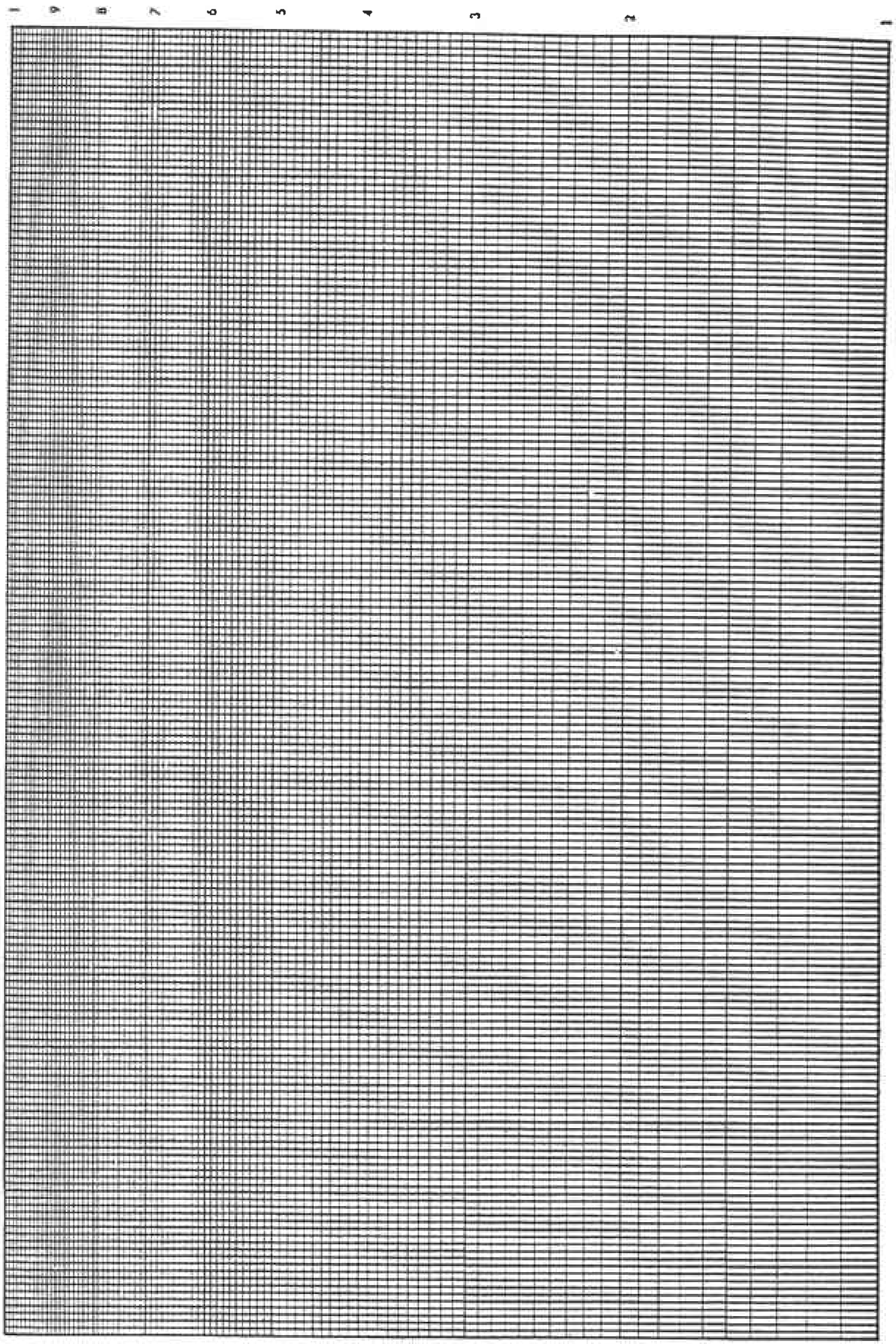


Table 2.3 Conversion Factors for Permeability and Hydraulic Conductivity Units

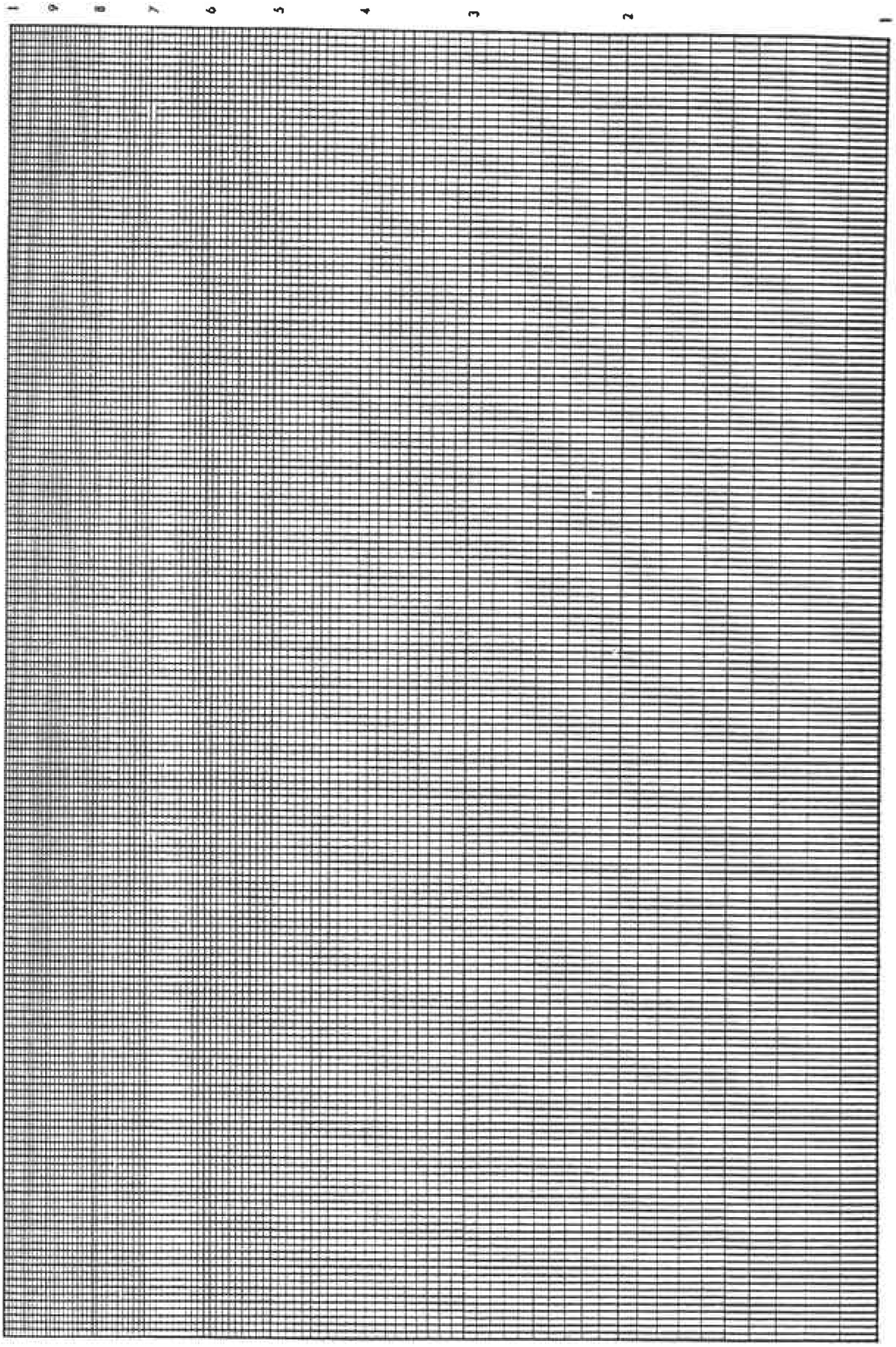
	Permeability, k*			Hydraulic conductivity, K		
	cm²	ft²	darcy	m/s	ft/s	U.S. gal/day/ft²
cm²	1	1.08×10^{-3}	1.01×10^{8}	9.80×10^{2}	3.22×10^{3}	1.85×10^{9}
ft²	9.29×10^{2}	1	9.42×10^{10}	9.11×10^{5}	2.99×10^{6}	1.71×10^{12}
darcy	9.87×10^{-9}	1.06×10^{-11}	1	9.66×10^{-6}	3.17×10^{-5}	1.82×10^{1}
m/s	1.02×10^{-3}	1.10×10^{-6}	1.04×10^{5}	1	3.28	2.12×10^{6}
ft/s	3.11×10^{-4}	3.35×10^{-7}	3.15×10^{4}	3.05×10^{-1}	1	6.46×10^{5}
U.S. gal/day/ft²	5.42×10^{-10}	5.83×10^{-13}	5.49×10^{-2}	4.72×10^{-7}	1.55×10^{-6}	1

*To obtain k in ft², multiply k in cm² by 1.08×10^{-3}.

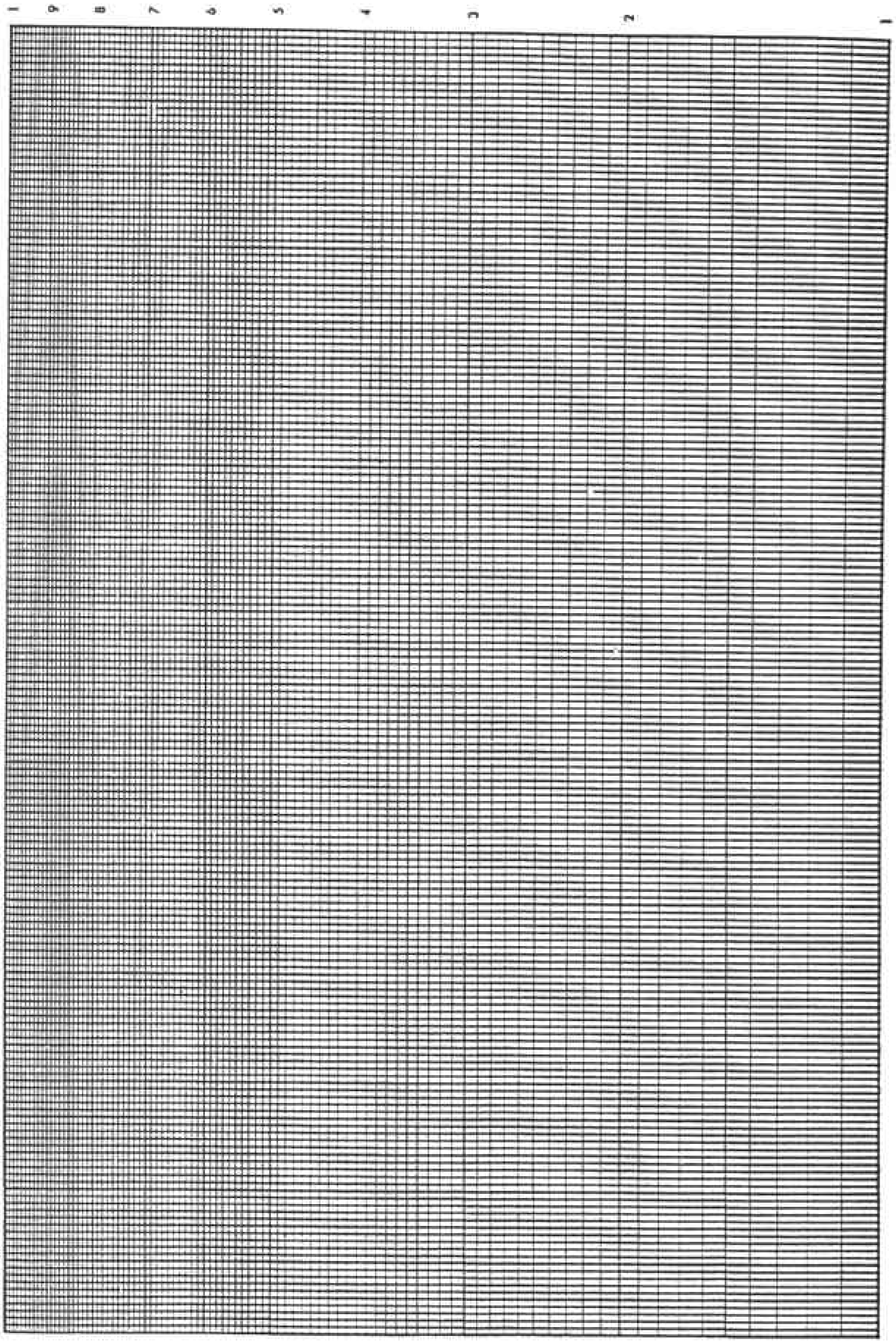
180 Divisions 5th, 10th Accent by 1 Cycle Semi-Log



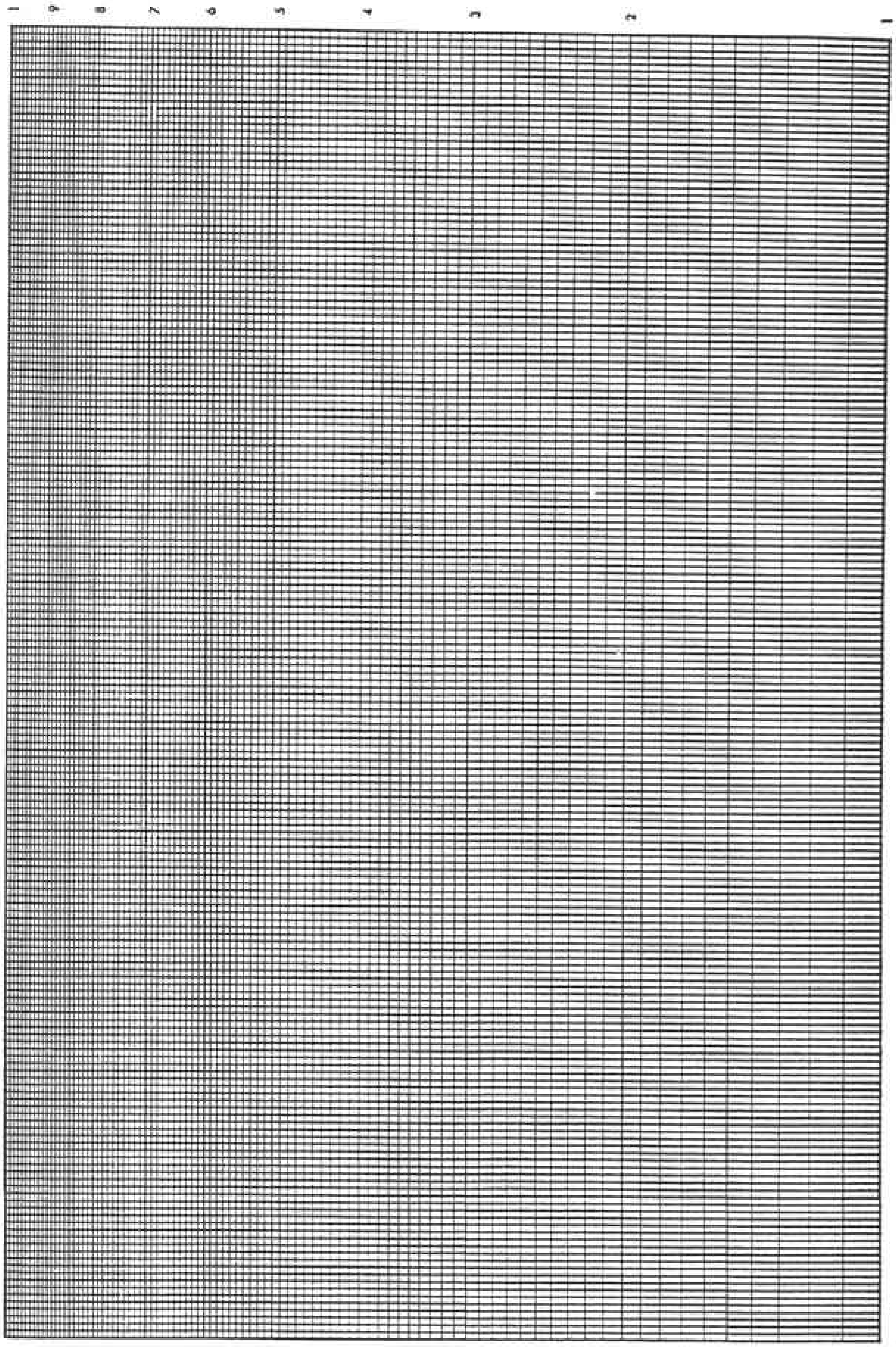
180 Divisions 5th, 10th Accent by 1 Cycle Semi-Log



180 Divisions 5th, 10th Accent by 1 Cycle Semi-Log



180 Divisions 5th, 10th Accent by 1 Cycle Semi-Log



180 Divisions 5th, 10th Accent by 1 Cycle Semi-Log