KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 79-6

DESCRIPTION AND ANALYSIS OF AQUIFER TESTS CONDUCTED BY THE KANSAS GEOLOGICAL SURVEY IN STAFFORD AND PAWNEE COUNTIES, KANSAS

by

Patrick M. Cobb

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OF
79-6

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KGS Open File Report

Open File Report of Pump Tests Conducted

by the KGS, Summer 1979

Acknowledgment

The work involved in organizing, setting up, conducting, and analyzing a pump test is considerable. There are many people with whom I wish to share credit for this set of tests, and without whose aid and cooperation this project could not even have begun. These people range from private citizens, to employees of the Kansas Geological Survey, the United States Geological Survey, the Big Bend Groundwater Management District #5, and the Division of Water Resources, State Board of Agriculture field office at Stafford, Kansas. I would especially like to thank the following people for their cooperation: Mr. Richard Sloan, Manager, Groundwater Management District #5; Mr. R. D. Bookstore; and Mr. Kyrle Froetschner, both cooperating irrigators in Groundwater Management District #5.

Preface

When attempting to construct a hydrogeological model of a study area, whether extensive or restricted in size, the most difficult data to obtain are the precise hydrogeological boundaries and the aquifer parameters. Most other data can be obtained, or at least approximated by diligently searching existing records. Therefore, when feasible, a pump test, or series of pump tests, is a most valuable addition to a hydrogeological study. A totally successful test will, if properly designed, yield significant information about the importance of hydrogeological boundaries and the values of various aquifer parameters.

The Kansas Geological Survey, in cooperation with the Big Bend Groundwater Management District, is conducting two hydrogeological studies in that district; and, it was thought that additional aquifer parameter data would be helpful in the conduction and completion of these studies. At the same time, the Groundwater Management District is conducting an irrigation scheduling study. This study has involved the installation of flow meters (McCrometer, Inc., Aurora, Nebraska) on the wells of several irrigators throughout the Pawnee Valley and the western portion of the Great Bend Prairie. Since there existed metered irrigation wells and a need for more data, the decision was made to do two pump tests.

If the analysis and evaluation of data is the most time-consuming part of a pump test, the most expensive part, and hence, the controlling factor is the expense of installing a pumping well of sufficient capacity to place a significant stress on the aquifer capacity. The cooperation of local irrigators with metered wells in the Pawnee Valley and in the western part of the Great Bend Prairie removed this expense and made

the pump test project a feasible idea. A suitable well was located in each region and then fitted with a series of observation wells. A float recorder (courtesy of the USGS) was maintained at each site for two months prior to the tests. When the cooperating irrigators felt ready to apply water to their crops, the tests were conducted.

Although such an arrangement is by no means fool-proof, the results are not unacceptable. Problems with each test will be discussed in the appropriate section. It would be useful to continue with this type program as more cooperating irrigators become available.

This report is in two independent parts, each with its own maps and figures. It is being filed as an Open File Report with the Kansas Geological Survey so that it will be available to any interested party.

Methods of Analysis

The methods used to analyze the data obtained in the test are outlined here in order to avoid repetition in the individual reports to follow. These are merely intended as brief introductions to the methods. For more detail, the reader should reference texts on groundwater hydrology or special articles referenced below.

1) The Jacob-Cooper method (Jacob and Cooper, 1946) is based upon the Theis formula, but is somewhat restricted since it utilizes the fact the exponential integral, which can be expanded in a convergent series, may be reduced, for small values of u, to the form

$$W(u) = (-0.5772 - \ln u) \qquad (u \leq 0.1)$$

Thus, the expression for the drawdown s takes on the assymtotic form

$$s = (Q/4\pi T)(-.5772 - \ln(r^2/4Tt)) \quad , \; u = r^2/4Tt$$

which is valid as long as the restrictions on u hold. It may be noted that for a given T, u decreases directly in proportion to t and inversely in proportion to r^2.

2) Chow's method (Chow, 1952) is also based upon the Theis equation and has all the basic restrictions imposed by the assumptions made by Theis. Chow introduced the function

$$F(u) = W(u)e^u/2.30 = s_A/\Delta s_A$$

where s_A is the drawdown at a point A on a time-drawdown curve, and Δs_A is the slope of the time-drawdown curve at A over one log cycle. The relation between F(u), W(u), and u is tabulated or gotten from a nomogram. Values of S and T are then derived by the appropriate formulae. Since this method does not use a truncated series expression for W(u), it is much less restricted than the Jacob-Cooper method.

3) The recovery method of Theis (1935) is based on the viewpoint that the recharging of the cone of depression may be considered due to

a recharging well, in place of the pumping well, with a recharge rate equal to the average discharge rate of the pumping well. Hence, the residual drawdown s" may be measured at some time t" after pumping ceases. All of the basic restrictions on the aquifer as imposed by Theis apply and the storage coefficient cannot be computed. The method is applied to the early time recovery data. See any standard text on pump test methods for more discussion.

4) The unsteady solution is based on work by C. V. Theis (1935) and involves fitting time-drawdown data pairs to a theoretical curve of W(u) vs. 1/u. It utilizes all of the time-drawdown data, but it achieves best results after the pumping rate has stabilized, and if non-linear conditions near the well screen are avoided. Strictly speaking, the method is correct only for confined, infinite, isotropic, and homogeneous aquifers under study pumpage and with instantaneous release of water from storage. The method is acceptable for unconfined aquifers so long as drawdown is only a small percentage of saturated thickness. When this condition is not met, a correction may be applied (Jacob, 1944). This correction was not applied in this study.

Drawdown (s) versus r^2/t is plotted on log-log paper and overlain on the standard "type curve." A match point is selected when the data points approximate the alignment of the curve. The values of W(u), 1/u, S, and r^2/t are used to solve for S and T.

5) A computer method which fits time-drawdown data to the standard Theis curve has been developed by the Kansas Geological Survey (McElwee, 1978). This method combines sensitivity theory with a least squared error procedure to fit experimental time-drawdown data to the Theis curve via a digital computer. This method computes a standard deviation,

which indicates the "goodness of fit" in an objective fashion. All data is given equal weight in the computations so that results are sensitive to scatter as well as curve alignment. Initial guesses for transmissivity (T) and storage coefficient (S) are typically supplied by the user; but this is not necessary, as an automatic initial guess routine based on the Jacob-Cooper method is included. The radius of convergence about tru S and T values is in the nieghborhood of two orders of magnitude. Thus, the initial guesses can be off by a factor of 100 and still converge to the true values with acceptable standard deviation and computer time usage.

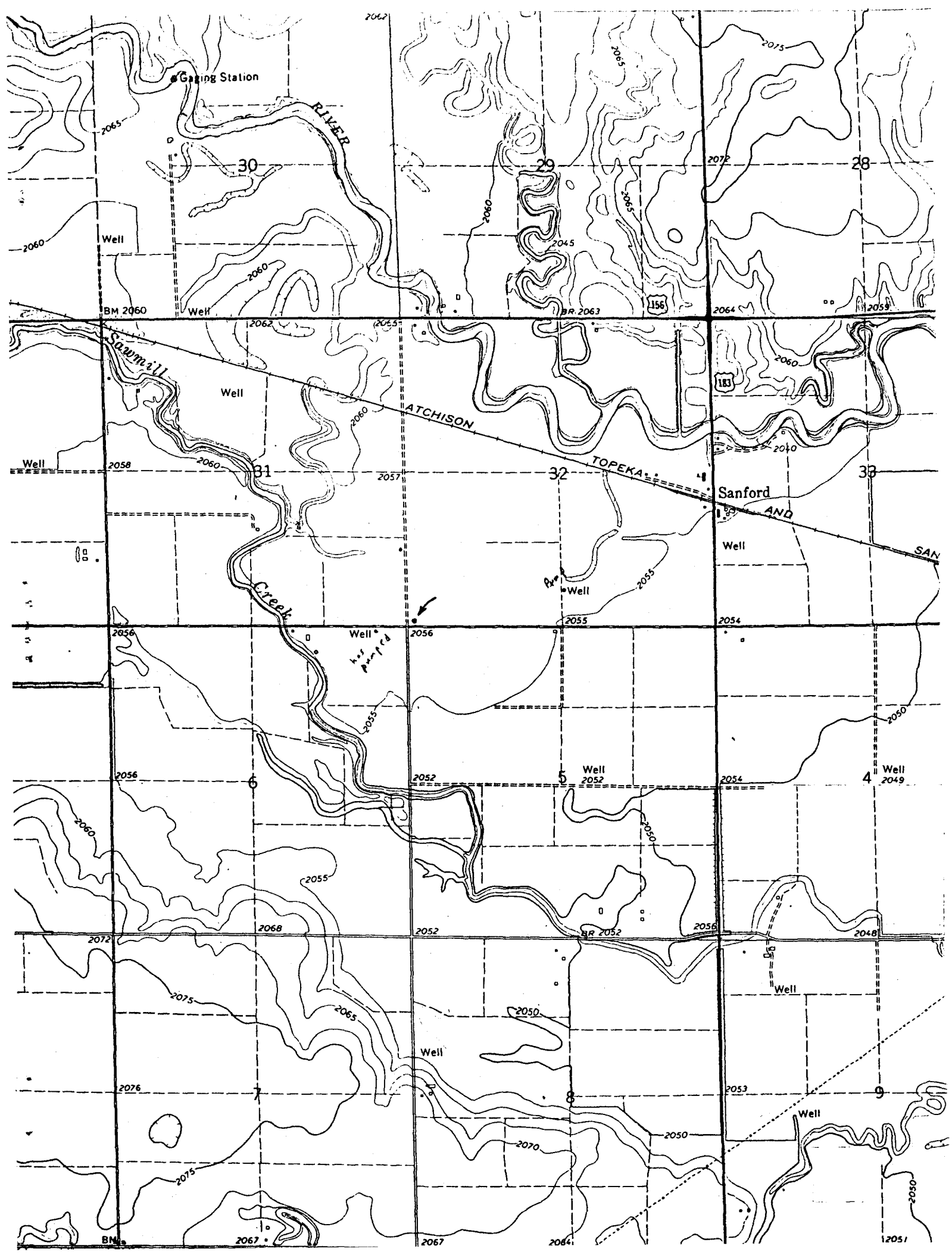
The methods outlined here were thought to be the most appropriate ones given the quantity and quality of data used and the low degree of complexity of the tests. Since there was no firm evidence of leakage or delayed yield, these methods were not addressed. Since only one-dimensional observation well arrays were used, no attempt was made to establish position and type of possible boundaries.

Test 79A

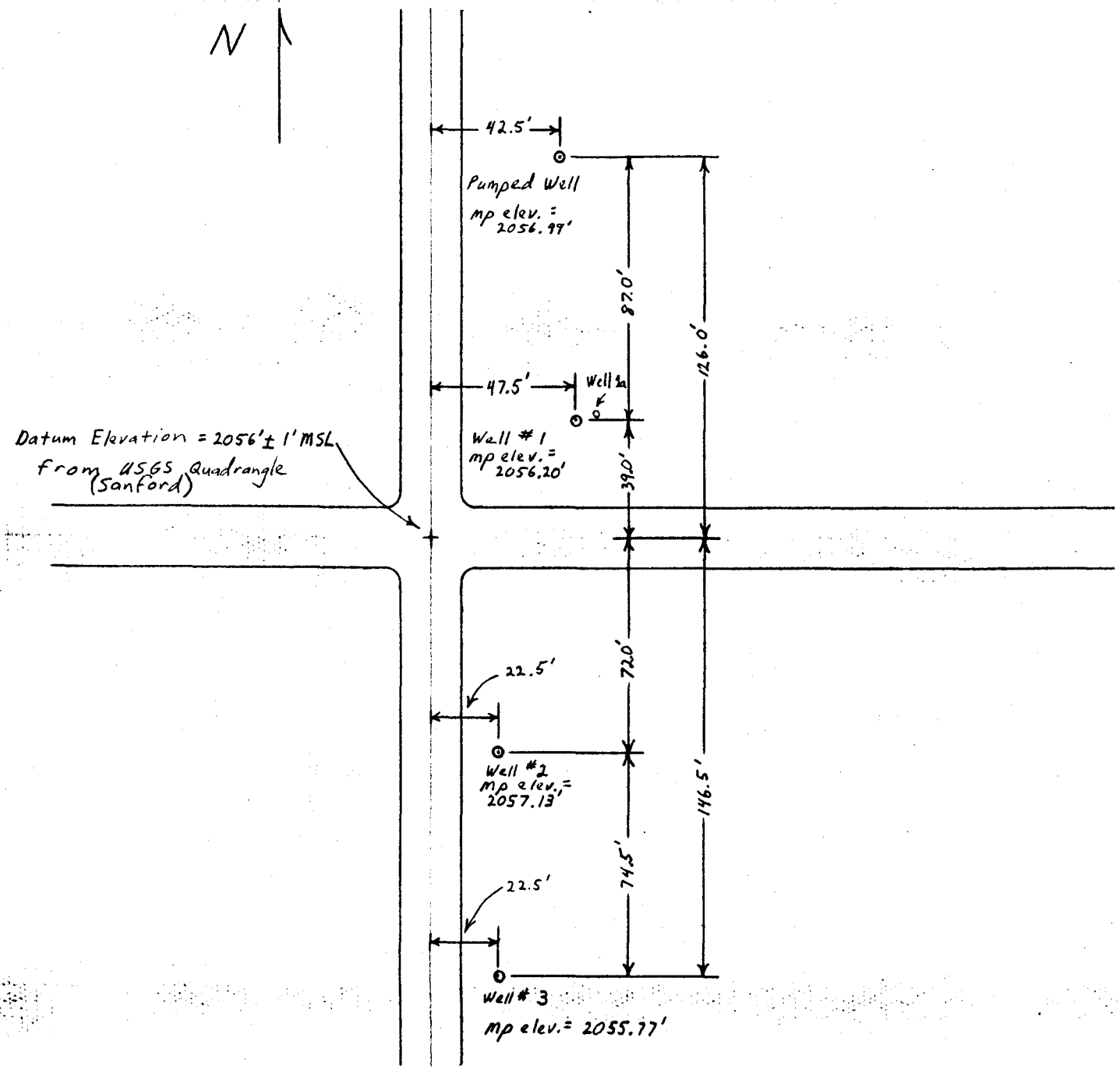
Introduction

This pump test commenced on June 18, 1979 at 8:50 a.m. and terminated on June 21, 1979 at 11:27 a.m., for a total of 4,477 minutes of operation. The land and well used for the test are owned by Mr. Kyrle Froetschner of Rozel, Pawnee County, Kansas. The legal description of the pumping well is T21-R18W-32CCC. A detailed plan of the pump test site is included (Fig. A-1), as well as a location map, consisting of a segment of the USGS Sanford, Kansas quadrangle (Fig. A-2). The pumping plant consists of a 16" cased gravel packed well. A Western Land Roller pump is directly driven by a General Electric induction motor rated 32 h.p. at 1750 rpm. A McCrometer flow meter is installed in the discharge line far enough away from the oriface to reduce turbulence. No tachometer was operated on the unit, nor was any output shaft available for such measurement by a hand-held tachometer. Because of the nature of an induction motor, however, we may expect a fairly steady motor speed. After clearing the discharge line, the pumping stabilized at about 1010 gpm. This condition lasted for a considerable, but not well documented time. At 3000 minutes, a pump rate of about 975 gpm was noted and was sustained until the end of the test. The test terminated with the pumping plant still in operation.

Observation wells were installed at this site on 29 March, 10 April and 17 april, 1979. An auger rig was used to install three shallow wells, which were cased with steel or PVC, and a rotary drill rig was used to install a deep well cased with PVC. A float recorder was operated on the deep well for several weeks before the test, although


Gaging Station
RIVER
30
29
28
Well
BM 2060
Well
BR 2063
156
2064
2059
Sawmill
Well
ATCHISON
TOPEKA
183
2040
Well
2058
31
32
33
Sanford
AND
SAN
Well
Creek
Well
has pumped
Well
2055
2054
2056
Well
2056
2055
2050
2056
6
2052
5
Well
2052
2054
4
Well
2049
2060
2055
2050
2068
2052
BR 2052
2056
2048
2072
2075
2065
2050
Well
2076
7
8
2053
9
Well
2050
2070
2075
2050
BM
2067
2067
2084
2051

Kyrle Froetschner Well
Pawnee County, Kansas
T 21 - R 18W - Sect. 32 - CCC
Scale: 1 inch = 50 feet



lack of manpower made it impossible to keep continuous records. Observation well 1a, a shallow well, was not utilized in this test. At this point, it is not clear whether or not any useful information could have been gotten from this well, since the log of observation well #1 showed no intervening confinement by clay.

Geo-hydrology

The geo-hydrology of the lower Pawnee Valley is known to be of a complex nature. The valley is cut into the Dakota Formation of Cretaceous Age and filled with alluvium of Pleistocene and Recent Age. Although not a great number of logs are available for reference in this immediate area, the drillers log of the deep test hole and the pumping well (Appendix A-1) indicate a complex geomorphology. Two principle features can be noted from examination of these logs. The log of the pumping well indicates a blue-grey clay (44'-78') and a brown clay (106'-114'). These clays do not appear in the deep test hole drilled 87 feet south of the pumping well. The total thickness of the lower clay is unknown. The dimensions and shapes of these units are unknown, but they may represent ancient silted up meanders or banks and are probably significant as local barrier boundaries. The second important feature is the depth of the test hole. Besides the lack of evidence of the above mentioned clays, there is also the fact that no bedrock is encountered after 166' of drilling. This may be evidence of a buried ancient channel. The absence of the clays may indicate a series of interconnected buried channels and from a hydrological point of view, may represent an area of high transmissivity. There may also be a high underflow through this unit. The small draw-

downs in the observation wells, the sustained high yield, and the number of inflections in the Theis curve, indicate a very complex geohydrology. There are also discrepancies in the derived values of T and S which indicate high recharge or anisotropies of the aquifer.

Conducting the Pumptest

Conditions of the pumptest make the results suspect on several counts. In general, it is preferable to conduct a pumptest on an aquifer which is in some degree of dynamic equilibrium. That is, there are no residual cones of depression from previous pumping nor is there any other pumping occurring before or during the test, except for the test well. Furthermore, in order for many analytical methods to be properly applied, a relatively horizontal potentiometric surface should exist prior to starting the test. Finally, the discharge water should be removed far enough from the well to prohibit a recharge effect.

At least three instances of previous pumping are known to have occurred within ½ mile of the test well, one of which was the test well itself. It is not known how much recovery had occurred before the test started. The test well was shut off only eight hours before the test started. Furthermore, it is not known to what extent the irrigation water had infiltrated to become a potential recharge source.

During the test two other wells pumped: one well ¼ mile north of the test well and the other ½ mile east. The irrigation water from the test well was applied to an already irrigated field ¼ mile to the north. Although the weather was hot and the unirrigated soil dry, the corn was not greatly stressed, due to previous irrigation.

A recording aneroid barometer was set up at the site the day of the test, but since no pre-pumping record was available, the barometric efficiency of the aquifer is unknown. However, if the aquifer is largely unconfined, this factor is not important.

The float recorder did not prove sensitive enough to record the minute initial drawdowns. It was not operated during the majority of the test. The lack of sensitivity caused some early time data on the near observation well (#1) to be of questionable value.

The test was terminated when it was felt that the aquifer had been stressed enough to reveal its more pertinent features and achieve late time values of its parameters. Analysis of the data indicates that a longer pumping period, a more sophisticated well array, and a more controlled test environment may have given more useful results.

Analysis of Data

The data analyzed in this section is tabulated in Appendix A-2. The various methods used are outlined in "Methods of Analysis" (just after the Preface). The results of the analyses will be discussed here.

All available data was plotted on semi-log graph paper (Appendix A-3) and the Jacob-Cooper and Chow methods were applied. Results are tabulated below (Table A-1).

Table A-1

Summary of Semi-Log Analysis Methods

Froetschner #1

Method	Range of t (min)	T (ft^2/min)	S (unitless)
J-C	10^1 - 10^2	608	.9
J-C	10^2 - 10^3	53.8	1.6
J-C	10^3 - 10^4	10.45	2.43
Chow	10^2 - 10^3	49.8	1.68
Chow	10^3 - 10^4	6.9	3.22

The data range $10^1 \leq t \leq 10^2$ was also plotted on an expanded scale and the Jacob-Cooper method was again applied. The results were $T = 343$ ft^2/min, $S = 1.34$. All of the above results are physically impossible under normal terrestial conditions. Apparently, enough of the assumptions on which these analytical methods are based have been violated to the extent that the formulae are no longer valid.

The data was also plotted on log-log graph paper so that the Theis curve matching procedure could be applied (Appendix A-3). The results are tabulated in Table A-2. No improvement is noted over the previous results.

Table A-2

Theis Curve Fitting Results for Froetchner #1

Curve Segment	T (ft^2/min)	S
1	64.6	2.58
5	297	.018
6	6.10	4.39

While several realistic values of T and S appear in Table A-2, they do not occur as a pair, and the remaining values appear totally unrealistic under normal conditions. The spread of data points for observation wells #2 and #3 is too poor to be diagnositc, and hence, was not analyzed.

The computer fitted data gave results no more encouraging than those tabulated above. The algorithm was run in two forms: 1) it was given initial guesses for S and T and allowed to converge, and 2) it was given initial guesses and forced to stop after one attempt at convergence. Graphs of results appear in Appendix A-4 along with the computer output. The output is tabulated in Table A-3.

Table A-3

T and S Obtained by Computer Fit

Modification	no. pts.	T	S	Standard Deviation
Normal Convergence	48	23260 ft^2/day	1.0	.384 ft
Forced Termination	48	41727 ft^2/day	0.29	.554 ft
Forced Termination	29	53439 ft^2/day	0.24	.574 ft

Although the S values for the second and third exhibits are reasonable, the associated T values seem too high, and the data for Exhibit #1 is unreasonable.

Conclusions

The aquifer parameters obtained from this pumptest are entirely out of reason. This is a reflection of the fact that the controlling assumptions in the analytical methods are too strict for the data. No steady state trend was noted in the data, so no attempt was made to apply delayed yield or leaky storage assumptions to the data. Since only a single line of observation wells was used, methods of analyzing anisotropies were not applied. There probably exists, however, a large degree of anisotropy. This would not be unusual in the Pawnee Valley. Insofar as it yields numerical values for specified aquifer parameters, the test fails. As an indicator of geo hydrologic complexity, the test succeeds. The many inflections in the data plots and the high sustained yield imply a complexity of barrier and recharge boundaries.

Test Hole Drilled on Froetschner Land

SW corner, SW/4 32-T21S-R18W

1 mile south, 1 mile west of Sanford Coop

T.D. = 166 ft. No bedrock encountered

Depth (ft)	Geology	Drill Time
0-3	Soil, dark brown, silty with quartz arkose pebbles.	not checked
3-6	Silt, fine grained, tan, no sand.	not checked
6-18	Clay, tan, blocky with grit to 14 feet. Some gravel at 9 feet. Loamy from 14 to 18 feet.	not checked
18-21	Silt, tan, with angular, fine to medium sand sized grains. Amount of sand increases with depth.	not checked
21-26	Sand, angular to rounded, quartz and caliche with some fine brown silt.	not checked
26-33	Sand, mostly rounded quartz, light to dark grained, fine to medium grained, some gray silt.	not checked
33-34	Silt, tan, fine, clean.	not checked
34-39	Sand, fine to medium grained, rounded to angular, mostly smokey quartz, trace of brown silt.	not checked
39-46	Sand, same as above, but coarse, with fine quartz arkose gravel.	not checked
46-60	Same as above, but includes yellow flat rounded fine grained sandstone fragments.	not checked
60-76	Sand, coarse to fine, quartz arkose with fine quartz arkose gravel. Several clay lenses, gray to black, about 1 ft thick each. Occur at 61 ft, 65 ft and 70 ft.	2 minutes
76-91	Sand, coarse to fine, some coarse gravel, much fine gravel, all quartz arkose, many angular yellow limestone chips.	1 minute
91-106	Sand, quartz, mostly fine grained; some quartz arkose gravel lenses.	1 minute
106-121	Sand, quartz arkose, fine to coarse with fine q.a. gravel. Some cobbles at 110 ft. Light red sandy clay lense from 112.5-114.5.	2½ minutes
121-136	Sand and gravel as above. Limestone chips, scant fraction light red clay.	1¼ minutes
136-151	Same as above, probably with more clay and cobbles.	2½ minutes
151-166	Same as above, drilled slow for about 1 ft at 162 ft - probably clay.	not recorded

Bedrock not encountered.

Finished as 105' observation well with 6' slotted 2½" PVC commercial screen.

Drillers Well Log for: SW¼ 32-21-18W
Pawnee County
Owner: Kyrle Froetschner

Formation	Depth (ft.)
Top Soil	0-3
Brown Clay	3-26
Black Clay	26-29
Sand & Gravel	29-44
Black Grey Clay	44-78
Sand & Gravel	78-106
Brown Clay	106-114

Well Probably set @ 106'
Screened probably in Two S&G Layers

County : Pawnee, near Sanford
Location: T21 - R18W 32 ccc

Observation well no. 1
Pumped well no. Froetschner

Average Q 995 gpm r = 86.4 ft. r^2 = 7551.61

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/18/79	am 8:50	0			37.76	0			1065	W. in pumping well 37.1' prop
		1			—					
		2			—					
		3			—					
		4			—					
		5			—					
		6			—					
		7			—					
		8			—					
		9			—					
	am 9:00	10			37.71*	.01				
		12.5			—					
		15.0			—					
		17.5			—					
		20.0			37.78*	.02				
		22.5			—					
		25.0			—					
		27.5			—					
		30.0			—					
		32.5			—				1015	lost 50 gpm [illegible] line cleared [illegible]
		35.0			37.78*	.02				
		37.5			—					
	am 9:30	40.0			—					
		46½			37.8	.04				
6/18/79	am 9:40	50			37.8	.04			1010	

* interpolated from recorder chart.

Figure 3.—Continued.

County : _____ Observation well no. _____

Location: _____ Pumped well no. _____

Average Q _____ gpm r = _____ ft. r^2 = _____

Date	Hour	t (min)	t' (min)	t/t'	Depth to water	s (unadjusted)	Adjustment Δs	s' (adjusted)	Q (gpm)	Remarks
6/18/79		500			36.69	.09				
		585			36.70	.10				
	PM 6:50	600			36.69	.09				
		650			36.69	.09				[illegible] pumping well 12.1 ft. [illegible] by [illegible]
		700			36.71	.11				
		750			36.72	.12				
		800			36.73	.13				
		850			36.73	.13				
		900			—					
		950			—					
6/19/79	am 1:30	1000			36.73	.13				
		1250			36.74	.14				
		1500			36.76	.16				
		1750			36.79	.19				
		2000			36.81	.21				
		2250			36.84	.24				
6/20/78	am 2:30	2500			36.85	.25				
		2750			36.88	.28				
		3000			36.89	.29			980	
		3574			36.91	.31			975	
6/21/79	am 3:43	4013			36.95	.35			975	
		4475			36.96	.36				

Figure 3.—Continued.

County : Pawnee near Sanford Observation well no. 3
Location: T21-R18W-32 ccc Pumped well ~~no~~ Froetschner

Average Q 995 gpm r = 271.7 ft. r^2 =

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/18/79	am 8:50	0			34.23	0			1065	W.L. in pump 31.1' bmp
		1			—	—				
		2								
		3								
		4								
		5			—	—				
		6								
		7								
		8			—	—				
		9			34.23	0				
	am 9:00	10			—	—				
		12.5			34.23	0				
		15			34.24	.01				
		17.5								
		20								
		22.5								
	am 9:15	25								
		27.5								
		30								
		32.5							1015	Test 50 gpm more Line cleared of air
		35			1	V				
		37.5			34.24	.01				
	am 9:30	40			34.25	.02				
		45			34.23	0				
	am 9:40	50			34.24	.01				

Figure 3.--Continued.

County : _____ Observation well no. _____

Location: _____ Pumped well no. _____

Average Q _____ gpm r = _____ ft. r^2 = _____

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
		55			36.64	.04				
6/18/79	am 9:50	60			36.64	↑				
		65			36.64					
		70			36.64	.04			1005	
		75			36.65	.05				
		80			36.64	.04				
		85			36.65	.05			1010	
		90			36.65	.05				
		95			36.64	.04			1005	
		100			36.65	.05				
	am 10:55	125			36.65	.05				
		150			36.67	.07			1005	
		175			36.67	.07			1005	
		200			36.67	.07			1005	
		225			36.66	.06				
	PM 1:00	250			36.67	.07				
		275			36.67	.07				[illegible] .74 SMP by [illegible]
	PM 1:50	300			36.68	.08				
		325			36.68	.08			1005	
		350			36.67	.07				
		375			36.68	.08				
		400			36.68	.08				
		425			36.68	.08				
		450			36.68	.08				
	PM 4:45	475			36.69	.09				

Figure 3.—Continued.

County : Pawnee, near Sanford — Observation well no. 2

Location: T21-R18W-32 ccc — Pumped well ● Fretschner

Average Q 995 gpm r = 197.0 ft. r^2 =

Date	Hour	t (min)	t' (min)	t/t'	Depth to water	s (unadjusted)	Adjustment Δs	s' (adjusted)	Q (gpm)	Remarks
6/18/79	am 8:50	0			36.60	—			1065	WL in pumped well 1.1' top
		.5			36.60	0				
		2			36.63	.03				
		3.25			36.63	.03				
		4			36.64	.04				
		5			36.62	.02				
		6			36.63	.03				
		7			36.64	.04				
		8			36.65	.05				
		9			36.63	.03				
	am 9:00	10			36.63	.03				
		12.75			36.63	.03				
		15.0			36.65	.05				
		17.5			36.64	.04				
		20.0			36.63	.03				
		22.5			^	^				
		25.0								
		27.0								
		30.0								
		32.5							1015	lost 50 gpm water line cleared & air
		35.0								
		37.5								
	am 9:30	40.0			v	v				
		45.0			36.63	.03				
	am 9:40	50.0			36.64	.04				

Figure 3.—Continued.

Appendix A-2

Tabulated Time-Drawdown Data

Appendix A-1

Drillers Logs

County : _____ Observation well no. _____

Location: _____ Pumped well no. _____

Average Q _____ gpm r = _____ ft. r^2 = _____

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/18/79	9:45	55			37.80	.04				
	9:50	60			37.81	.05				
		65			^	^				
		70			v	v			1005	
		75			37.81	.05				
		80			37.80	.04				
		87			37.81	.05			1010	
		90			—	—				
		95			37.82	.06			1005	
	am 10:30	100			37.83	.07				
		125			37.83	.07				
		150			37.85	.09			1005	
		175			37.87	.11			1005	
	pm 12:10	200			37.89	.13			1005	
		225			37.90	.14				
		250			37.91	.15				
		275			37.91	.15				Water in pump 71.79' bmp
	pm 1:50	300			37.93	.17				
		325			37.94	.18			1005	
		350			37.98	.22				
		375			37.98	.22				
	pm 3:30	400			37.99	.23				
		425			38.00	.24				
		450			38.00	.24				
6/18/79	4:45	475			38.02	.26				

Figure 3.—Continued.

County :_____ Observation well no._____

Location:_____ Pumped well no. _____

Average Q_____ gpm r=_____ ft. r^2=_____

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/18/79	pm 5:10	500			38.02	.26				
		585			38.05	.29				
	pm 6:50	600			38.07	.31				
		650			38.09	.33				w.l. in pump column 12.7 ft bmp
	pm 8:30	700			38.10	.34				
		750			38.12	.36				
	pm 10:10	800			38.16	.40				
		850			38.20	.44				
	pm 11:50	900			—	—				
6/19/79	am 12:40	950			—	—				
	am 1:30	1000			38.24	.48				
		1250			38.27	.51				
		1500			38.48	.72				
		1750			38.50	.74				
		2000			38.61	.91				
		2250			38.78	1.02				
		2500			38.10	1.14				
		2750			38.99	1.23				
		3000			39.08	1.32			980	
		3568			39.28	1.52			975	
	3:	4000			39.43	1.67			975	
6/21/79	11:18	4968			39.61	1.85				

Figure 3.—Continued.

County :_____ Observation well no._____

Location:_____ Pumped well no. _____

Average Q_____ gpm r=_____ft. r^2=_____

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/18/79	am 9:45	55			34.25	0.02				
	am 9:50	60			^	^				
		65								
		70							1005	
		75								
		80								
		85							1010	
		90			↓	↓				
		95			34.25	0.02			1005	
	PM 10:30	100			34.26	0.03				
		125			34.26	0.03				
		150			34.25	0.01			1005	
		175			34.26	0.03			1005	
		200			34.27	0.04			1005	
		225			34.27	^				
		250			34.27					
		275			34.27					W.L. in pumped well 71.72 BTP by M-Scope
	PM 1:50	300			34.27	↓				
		325			34.27	0.04			1005	
		350			34.28	0.05				
		375			34.28	0.05				
		400			34.27	0.04				
		425			34.27	0.04				
		450			34.28	0.05				
6/18/79	PM 4:45	475			34.29	0.06				

Figure 3.—Continued.

County : _____ Observation well no. _____

Location: _____ Pumped well no. _____

Average Q _____ gpm r = _____ ft. r^2 = _____

Date	Hour	t (min)	t′ (min)	t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/18/79	PM 5:10	500			34.30	0.07				W.L. in pumping well 12.7 ft bmp by M-Scope
		585			34.30	↑				
		600			34.30	↓				
		650			34.30	0.07				
		700			34.32	0.09				
		750			34.32	0.09				
		800			34.33	0.10				
		850			34.32	0.09				
6/18/79	PM 11:50	900			—					
6/19/79	am 12:40	950			—					
		1000			34.34	0.11				
		1250			34.35	0.12				
		1500			34.37	0.14				
		1750			34.39	0.16				
		2000			34.41	0.18				
6/19/79	pm 10:20	2250			34.42	0.19				
6/20/79	am 2:30	2500			—					
		2750			34.46	0.23				
		3000			34.47	0.24			980	
6/20/79	pm 8:27	3577			34.50	0.27			975	
6/21/79	am 3:30	4000			34.53	0.30			975	
6/21/79	am 11:27	4477			34.54	0.31				

Figure 3.—Continued.

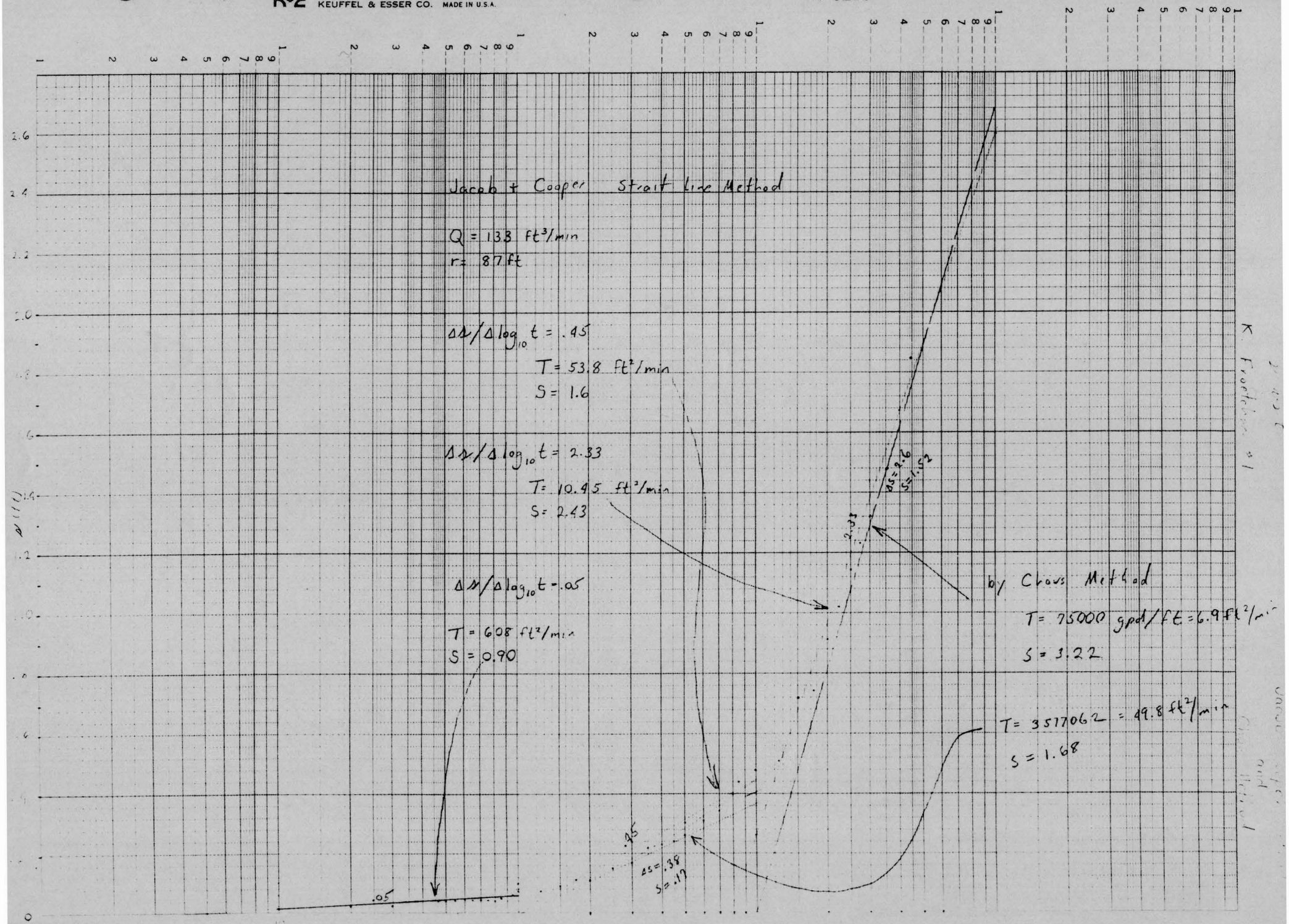
Appendix A-3

Data Plots with Solutions

and

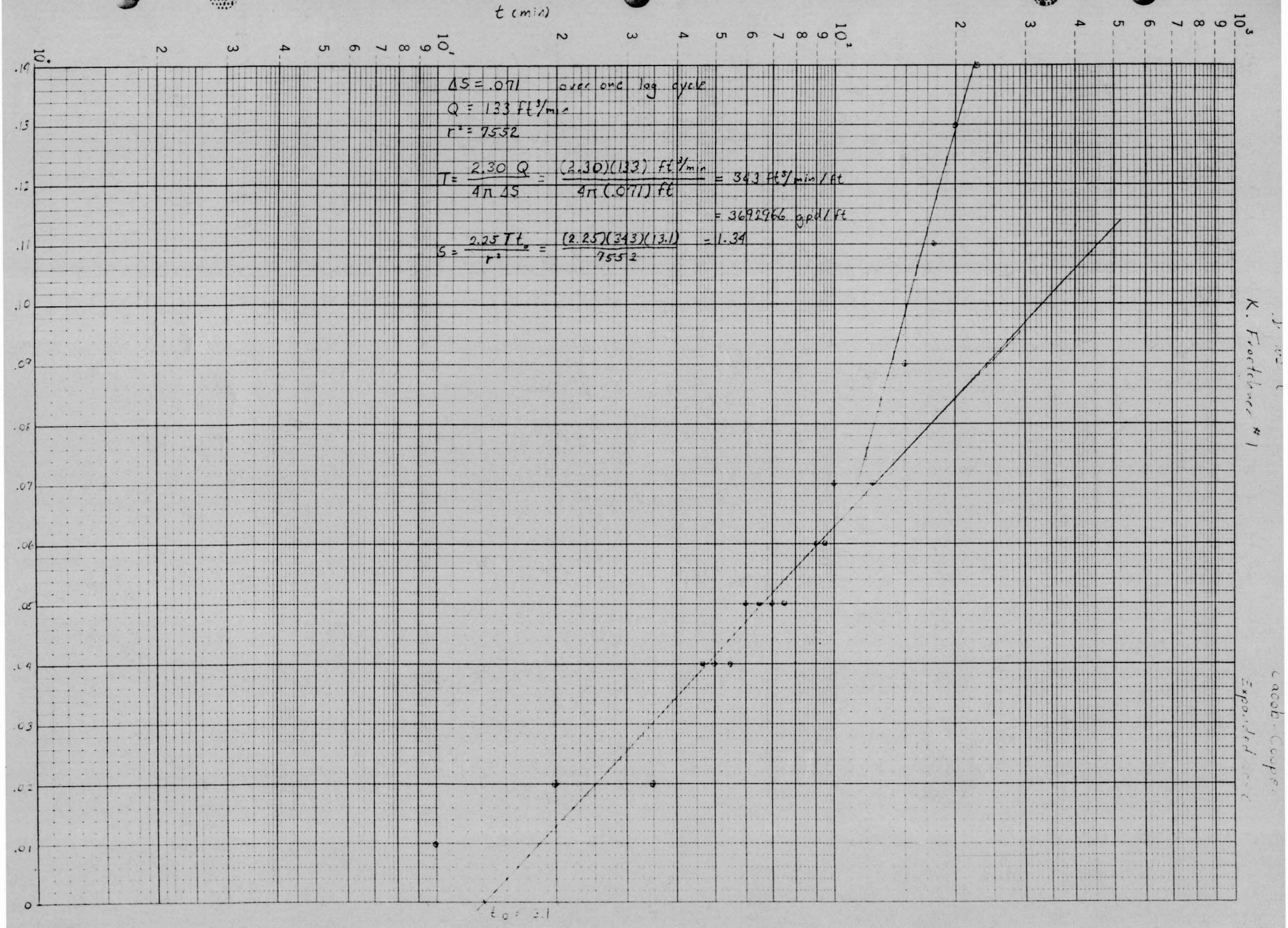
Graphs

K&E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6210



K•E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 5490



$\Delta S = .071$ over one log cycle

$Q = 133\ ft^3/min$

$r^2 = 7552$

$$T = \frac{2.30\,Q}{4\pi\,\Delta S} = \frac{(2.30)(133)\ ft^3/min}{4\pi\,(.071)\ ft} = 343\ ft^3/min/ft$$

$$= 3692966\ gpd/ft$$

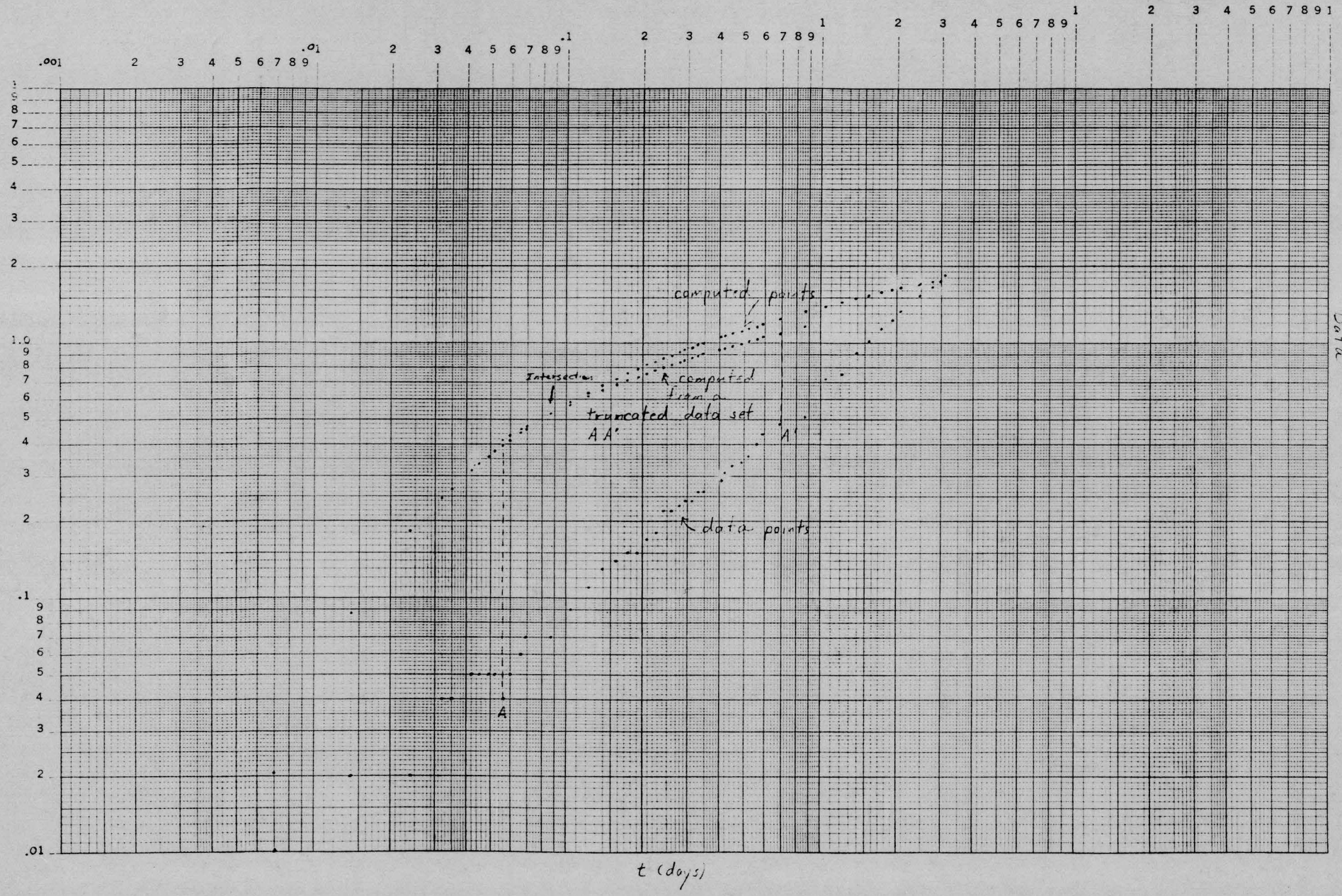
$$S = \frac{2.25\,T\,t_0}{r^2} = \frac{(2.25)(343)(13.1)}{7552} = 1.34$$

K. Frochtzner #1

Jacob-Cooper Extended

K&E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

S vs. t
Theoretical Curve Points
Plotted Against Experimental
Data



S (ft)

Appendix A-4

Computer Fitted Solutions

to

Data Sets

THE PUMP TEST DATA IN DRAWDOWN-TIME PAIRS IS

0.40000000E-01	0.56000000E-01
0.50000000E-01	0.60000000E-01
0.60000000E-01	0.66000000E-01
0.70000000E-01	0.69000000E-01
0.70000000E-01	0.87000001E-01
0.90000000E-01	0.10400000E 00
0.11000000E 00	0.12200000E 00
0.13000000E 00	0.13900000E 00
0.14000000E 00	0.15600000E 00
0.15000000E 00	0.17400000E 00
0.15000000E 00	0.19100000E 00
0.17000000E 00	0.20800000E 00
0.18000000E 00	0.22600000E 00
0.22000000E 00	0.24300000E 00
0.22000000E 00	0.26000000E 00
0.23000000E 00	0.27800000E 00
0.24000000E 00	0.29500000E 00
0.24000000E 00	0.31300000E 00
0.26000000E 00	0.33000000E 00
0.26000000E 00	0.34700000E 00
0.29000000E 00	0.40600000E 00
0.31000000E 00	0.41700000E 00
0.33000000E 00	0.45100000E 00
0.34000000E 00	0.48600000E 00
0.36000000E 00	0.52100000E 00
0.40000000E 00	0.55600000E 00
0.44000000E 00	0.59000000E 00
0.48000000E 00	0.69400000E 00
0.51000000E 00	0.86800000E 00

BEST FIT KB AND SC THIS ITERATION ARE 0.39972506E 06 0.24017891E 00

THE BEST FIT DRAWDOWN-TIME PAIRS ARE

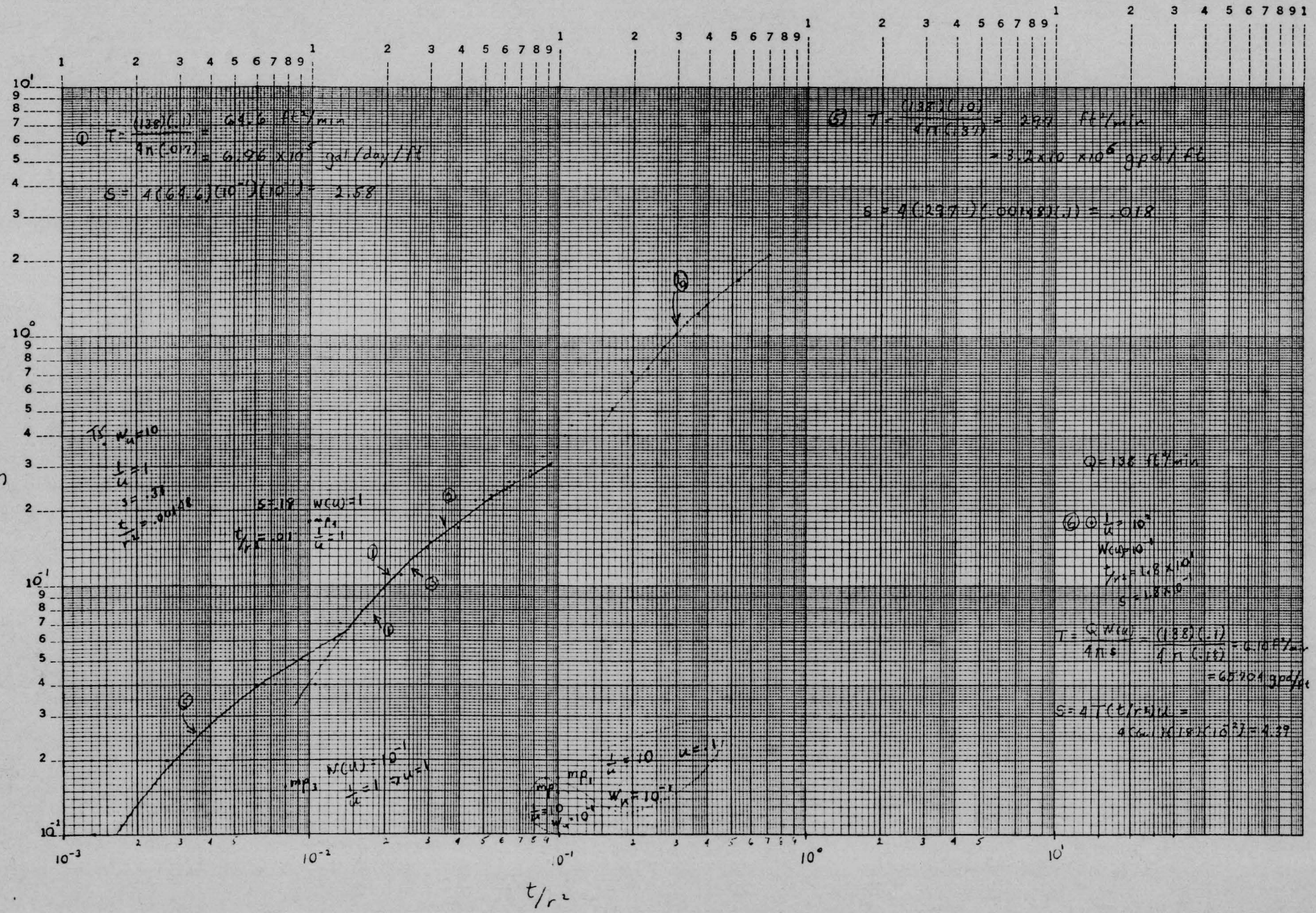
0.41469180E 00	0.56000000E-01
0.43168554E 00	0.60000000E-01
0.45543431E 00	0.66000000E-01
0.46661240E 00	0.69000000E-01
0.52584559E 00	0.87000001E-01
0.57239717E 00	0.10400000E 00
0.61461612E 00	0.12200000E 00
0.64947285E 00	0.13900000E 00
0.68053688E 00	0.15600000E 00
0.71011739E 00	0.17400000E 00
0.73549484E 00	0.19100000E 00
0.75879977E 00	0.20800000E 00
0.78156314E 00	0.22600000E 00
0.80151333E 00	0.24300000E 00
0.82015969E 00	0.26000000E 00
0.83865904E 00	0.27800000E 00
0.85509394E 00	0.29500000E 00
0.87152192E 00	0.31300000E 00
0.88621423E 00	0.33000000E 00
0.90018693E 00	0.34700000E 00
0.94397367E 00	0.40600000E 00
0.95144309E 00	0.41700000E 00
0.97336645E 00	0.45100000E 00
0.99430200E 00	0.48600000E 00
0.10138057E 01	0.52100000E 00
0.10320609E 01	0.55600000E 00
0.10487417E 01	0.59000000E 00
0.10944386E 01	0.69400000E 00
0.11575562E 01	0.86800000E 00

THE STANDARD DEVIATION FOR DRAWDOWN IS 0.57372146E 00

*

K+E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

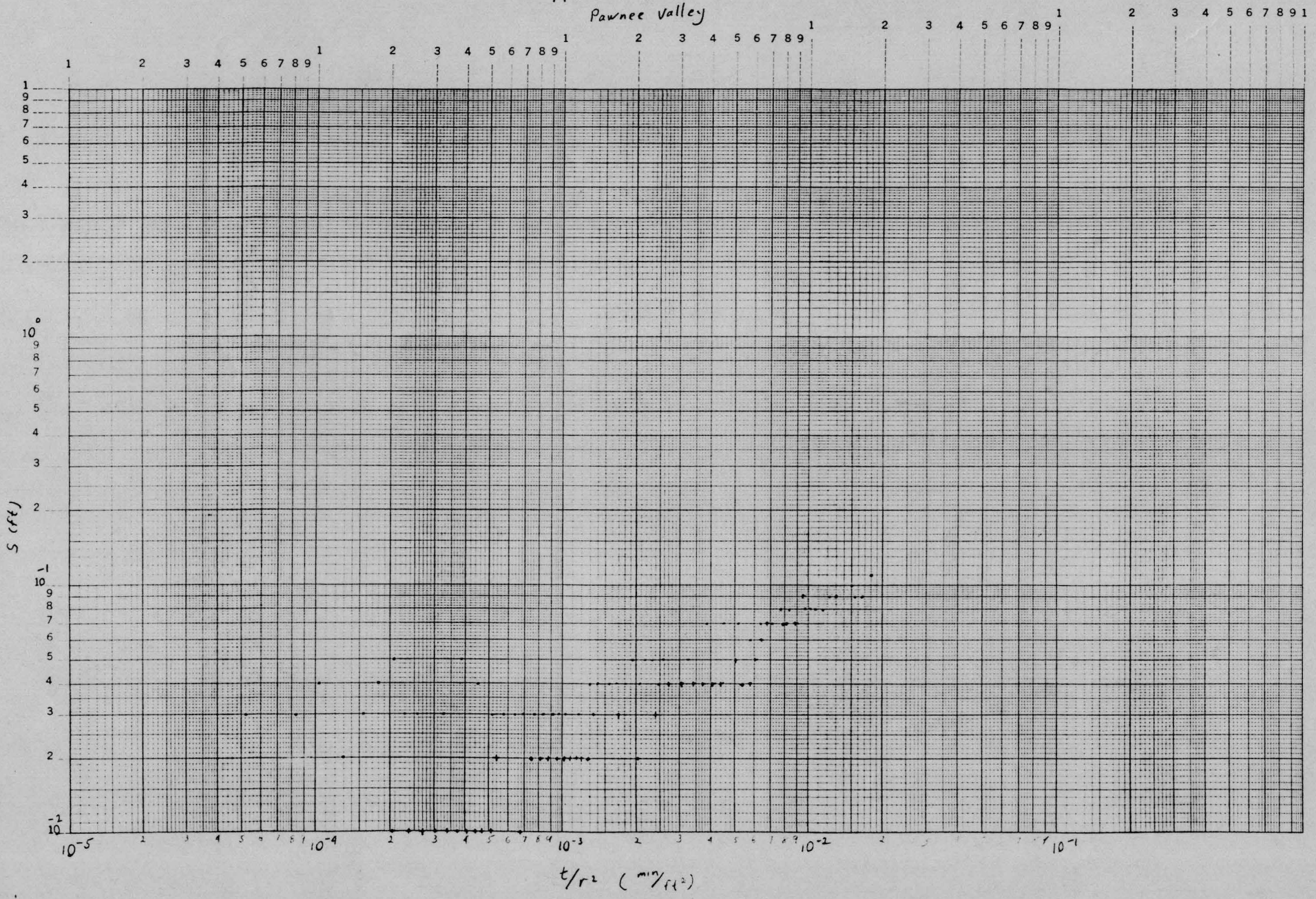
46 7522



K+E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7522

S vs t/r^2 for O.W. #2 & #3
Pawnee Valley



• = O.W. #2

+ = O.W. #3

S vs. t/r^2
Composit Plot, Frontier #2
and Frontier #3

0.44000000E 00	0.59000000E 00
0.48000000E 00	0.69400000E 00
0.51000000E 00	0.86800000E 00
0.72000000E 00	0.10420000E 01
0.75000000E 00	0.12150000E 01
0.91000000E 00	0.13890000E 01
0.10200000E 01	0.15630000E 01
0.11400000E 01	0.17360000E 01
0.12300000E 01	0.19100000E 01
0.13200000E 01	0.20830000E 01
0.15200000E 01	0.24780000E 01
0.16700000E 01	0.27780000E 01
0.18500000E 01	0.31030000E 01

BEST FIT KB AND SC THIS ITERATION ARE 0.31211496E 06 0.29303442E

THE BEST FIT DRAWDOWN-TIME PAIRS ARE

0.20579216E-01	0.70000000E-02
0.87332773E-01	0.14000000E-01
0.18247412E 00	0.24000000E-01
0.24747961E 00	0.32000000E-01
0.26948583E 00	0.35000000E-01
0.31656600E 00	0.42000000E-01
0.33513107E 00	0.45000000E-01
0.35857097E 00	0.49000000E-01
0.37525398E 00	0.52000000E-01
0.39641613E 00	0.56000000E-01
0.41645565E 00	0.60000000E-01
0.44464352E 00	0.66000000E-01
0.45797946E 00	0.69000000E-01
0.52928971E 00	0.87000001E-01
0.58598093E 00	0.10400000E 00
0.63780037E 00	0.12200000E 00
0.68083012E 00	0.13900000E 00
0.71934138E 00	0.15600000E 00
0.75614038E 00	0.17400000E 00
0.78779912E 00	0.19100000E 00
0.81693765E 00	0.20800000E 00
0.84545425E 00	0.22600000E 00
0.87048801E 00	0.24300000E 00
0.89391806E 00	0.26000000E 00
0.91719219E 00	0.27800000E 00
0.93789159E 00	0.29500000E 00
0.95860217E 00	0.31300000E 00
0.97714054E 00	0.33000000E 00
0.99478412E 00	0.34700000E 00
0.10501508E 01	0.40600000E 00
0.10596063E 01	0.41700000E 00
0.10873754E 01	0.45100000E 00
0.11139148E 01	0.48600000E 00
0.11386568E 01	0.52100000E 00
0.11618292E 01	0.55600000E 00
0.11830146E 01	0.59000000E 00
0.12411022E 01	0.69400000E 00
0.13214390E 01	0.86800000E 00
0.13872558E 01	0.10420000E 01
0.14427087E 01	0.12150000E 01
0.14911039E 01	0.13890000E 01
0.15338315E 01	0.15630000E 01
0.15718722E 01	0.17360000E 01
0.16065127E 01	0.19100000E 01
0.16379768E 01	0.20830000E 01
0.17010397E 01	0.24780000E 01
0.17425762E 01	0.27780000E 01
0.17828108E 01	0.31030000E 01

THE STANDARD DEVIATION FOR DRAWDOWN IS 0.55423943E 00

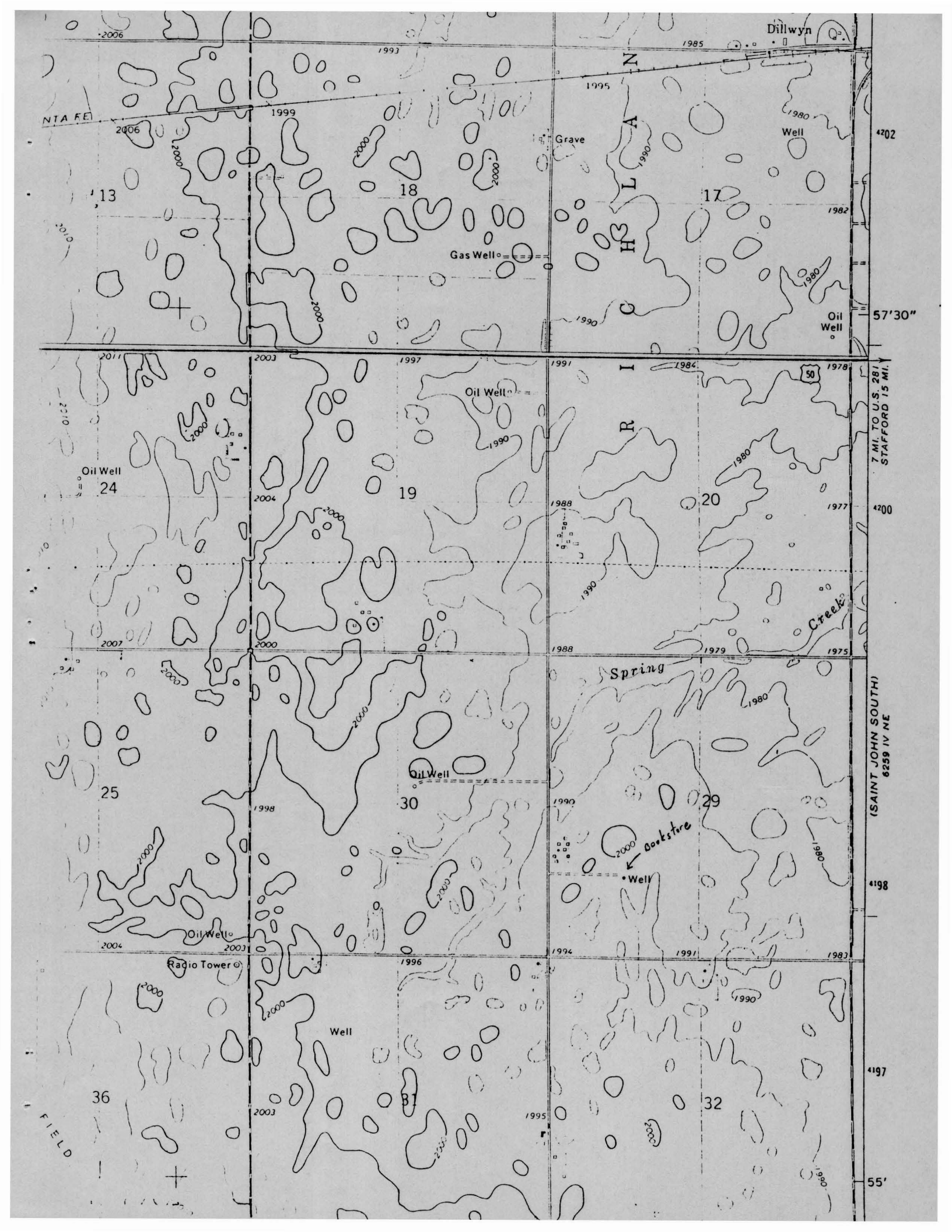
```
          0.15200000E 01       0.24780000E 01
          0.16700000E 01       0.27780000E 01
          0.18500000E 01       0.31030000E 01
     BEST FIT KB AND SC THIS ITERATION ARE   0.28723868E 06   0.14428989E 00
     BEST FIT KB AND SC THIS ITERATION ARE   0.31733361E 06   0.42884303E 00
     BEST FIT KB AND SC THIS ITERATION ARE   0.25205784E 06   0.10000000E 01
     BEST FIT KB AND SC THIS ITERATION ARE   0.17810172E 06   0.10000000E 01
     BEST FIT KB AND SC THIS ITERATION ARE   0.17520967E 06   0.10000000E 01
     BEST FIT KB AND SC THIS ITERATION ARE   0.17438507E 06   0.10000000E 01
     BEST FIT KB AND SC THIS ITERATION ARE   0.17413979E 06   0.10000000E 01
     BEST FIT KB AND SC THIS ITERATION ARE   0.17406596E 06   0.10000000E 01
     THE BEST FIT DRAWDOWN-TIME PAIRS ARE
          0.47079652E-06       0.70000000E-02
          0.29404471E-03       0.14000000E-01
          0.52459777E-02       0.24000000E-01
          0.15462283E-01       0.32000000E-01
          0.20637739E-01       0.35000000E-01
          0.35008413E-01       0.42000000E-01
          0.41973074E-01       0.45000000E-01
          0.51849164E-01       0.49000000E-01
          0.59623160E-01       0.52000000E-01
          0.70381214E-01       0.56000000E-01
          0.81494001E-01       0.60000000E-01
          0.98642369E-01       0.66000000E-01
          0.10736841E 00       0.69000000E-01
          0.16054037E 00       0.87000001E-01
          0.21026036E 00       0.10400000E 00
          0.26104968E 00       0.12200000E 00
          0.30680693E 00       0.13900000E 00
          0.35031035E 00       0.15600000E 00
          0.39397030E 00       0.17400000E 00
          0.43305536E 00       0.19100000E 00
          0.47019390E 00       0.20800000E 00
          0.50755471E 00       0.22600000E 00
          0.54113189E 00       0.24300000E 00
          0.57318172E 00       0.26000000E 00
          0.60558389E 00       0.27800000E 00
          0.63485139E 00       0.29500000E 00
          0.66453789E 00       0.31300000E 00
          0.69143720E 00       0.33000000E 00
          0.71731197E 00       0.34700000E 00
          0.80012124E 00       0.40600000E 00
          0.81449209E 00       0.41700000E 00
          0.85705435E 00       0.45100000E 00
          0.89820513E 00       0.48600000E 00
          0.93695888E 00       0.52100000E 00
          0.97357515E 00       0.55600000E 00
          0.10073076E 01       0.59000000E 00
          0.11009499E 01       0.69400000E 00
          0.12328914E 01       0.86800000E 00
          0.13427500E 01       0.10420000E 01
          0.14363434E 01       0.12150000E 01
          0.15186899E 01       0.13890000E 01
          0.15918456E 01       0.15630000E 01
          0.16572952E 01       0.17360000E 01
          0.17171301E 01       0.19100000E 01
          0.17716557E 01       0.20830000E 01
          0.18813935E 01       0.24780000E 01
          0.19539645E 01       0.27780000E 01
          0.20244555E 01       0.31030000E 01
     THE STANDARD DEVIATION FOR DRAWDOWN IS        0.38373594E 00

     *
```

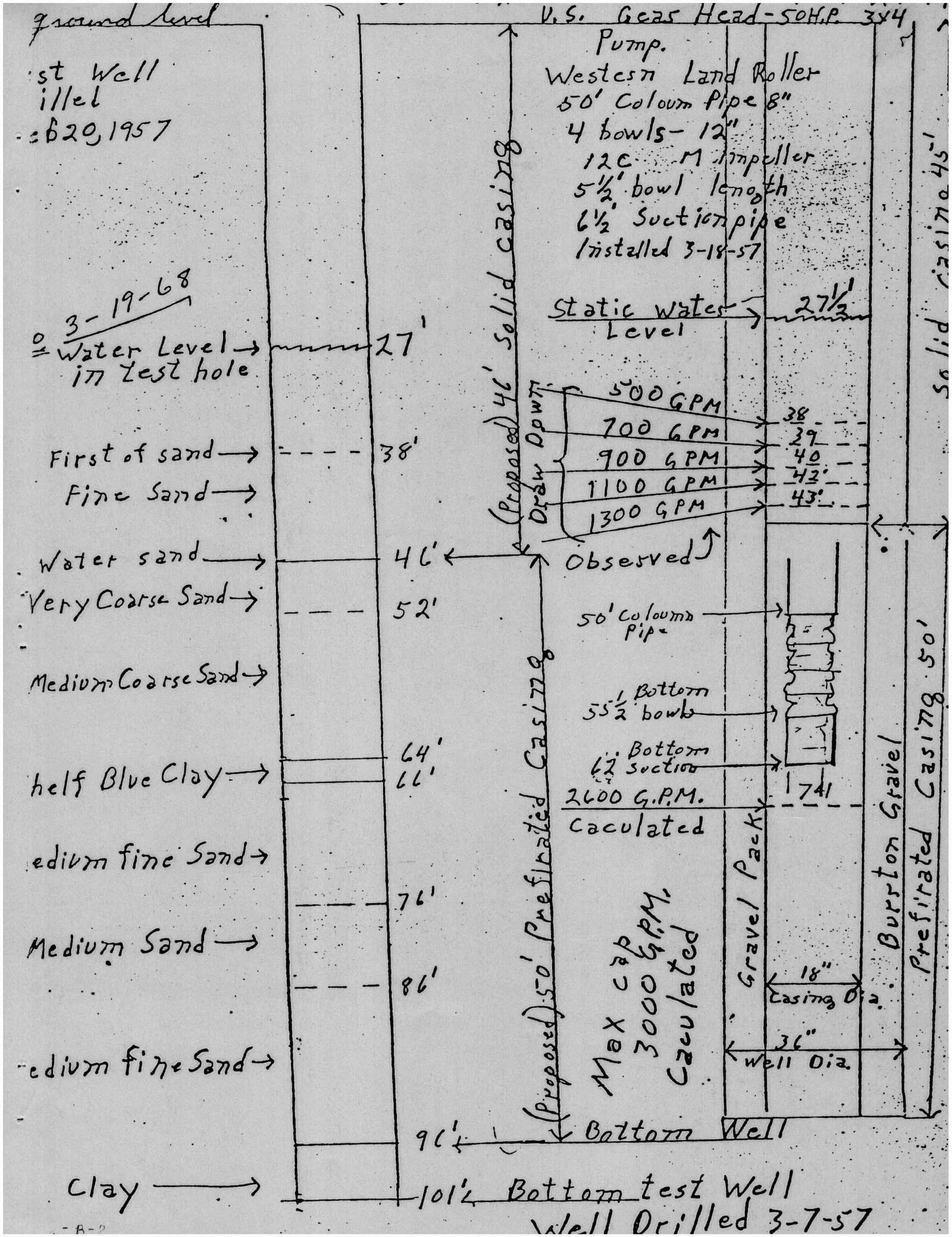
Test 79B

Introduction

This pump test was conducted on June 20, 1979 and was run from 8:55 a.m. until 2:52 p.m. for a total of 357 minutes. The land and well used for the test are owned by Mr. R. D. Bookstore of rural St. John, Stafford County, Kansas. The legal description of the pumping well is T24S-R14W-29c. A location map of the site is included (Fig. B-1). The well was completed in 1957. A technical sketch of the well as originally completed is included (Fig. B-2). As the well now exists, it is powered by a diesel engine. A Western Land Roller pump, set between 50' and 55.5' is driven through an Amarillo 6:5 right angle reduction gear and delivers water through an 8" pipe. The irrigation unit is a Valley center pivot of the high pressure type. When the end gun operated, the yield was about 725 gpm. Without end gun discharge, the yield was reduced to about 690 gpm. Engine speed was fairly constant at 2025 rpm. The test as planned was to last 66 hours. Engine failure cut the test short, but a recovery curve was recorded.

Observation wells were installed using an auger rig operated by the Kansas Geological Survey. The work was done on 27 and 28 March, 1979. The plan of observation wells is shown in Figure B-3. Details of the completion of the wells appear on the drillers nots included as Appendix B-1 . A float recorded was operated on observation well #1 as noted. A recording barograph was not utilized at this site, but, since the test was of short duration, the lack of this data is not crucial.


Dillwyn
NTA FE
Grave
Well
Gas Well
Oil Well
Oil Well
Oil Well
Creek
Spring
Oil Well
Bookstore
Well
Oil Well
Radio Tower
Well
13
18
17
24
19
20
25
30
29
36
31
32
57'30"
55'
4202
4200
4198
4197
7 MI. TO U.S. 281
STAFFORD 15 MI.
(SAINT JOHN SOUTH)
6259 IV NE
FIELD


ground level
st Well
illel
620, 1957
U.S. Geas Head-50H.P. 3x4
Pump.
Westesn Land Roller
50' Coloum Pipe 8"
4 bowls- 12"
12C M impeller
5½' bowl length
6½' Suction pipe
Installed 3-18-57
3-19-68
Water Level in test hole
27'
Static water Level
27½'
First of sand
38'
Fine Sand
Water sand
46'
Very Coarse Sand
52'
Medium Coarse Sand
64'
helf Blue Clay
66'
edium fine Sand
76'
Medium Sand
86'
edium fine Sand
96'
Clay
101'
(Proposed) 46' Solid casing
Draw Down
500 GPM
700 GPM
900 GPM
1100 GPM
1300 GPM
38
39
40
42'
43'
Observed
50' Coloumn Pipe
55½ Bottom bowls
62 Bottom suction
741
2600 G.P.M. Caculated
(Proposed) 50' Prefirated Casing
Max cap 3000 G.P.M. Caculated
Gravel Pack
18" Casing Dia.
36" Well Dia.
Burston Gravel
Prefirated Casing 50'
Solid casing 45'
Bottom Well
Bottom test Well
Well Drilled 3-7-57

R. D. Bookstore Well
Stafford County, Kansas

Center: SW ¼, Sect. 29, T24S, R14W
Scale: 1 inch = 200 feet

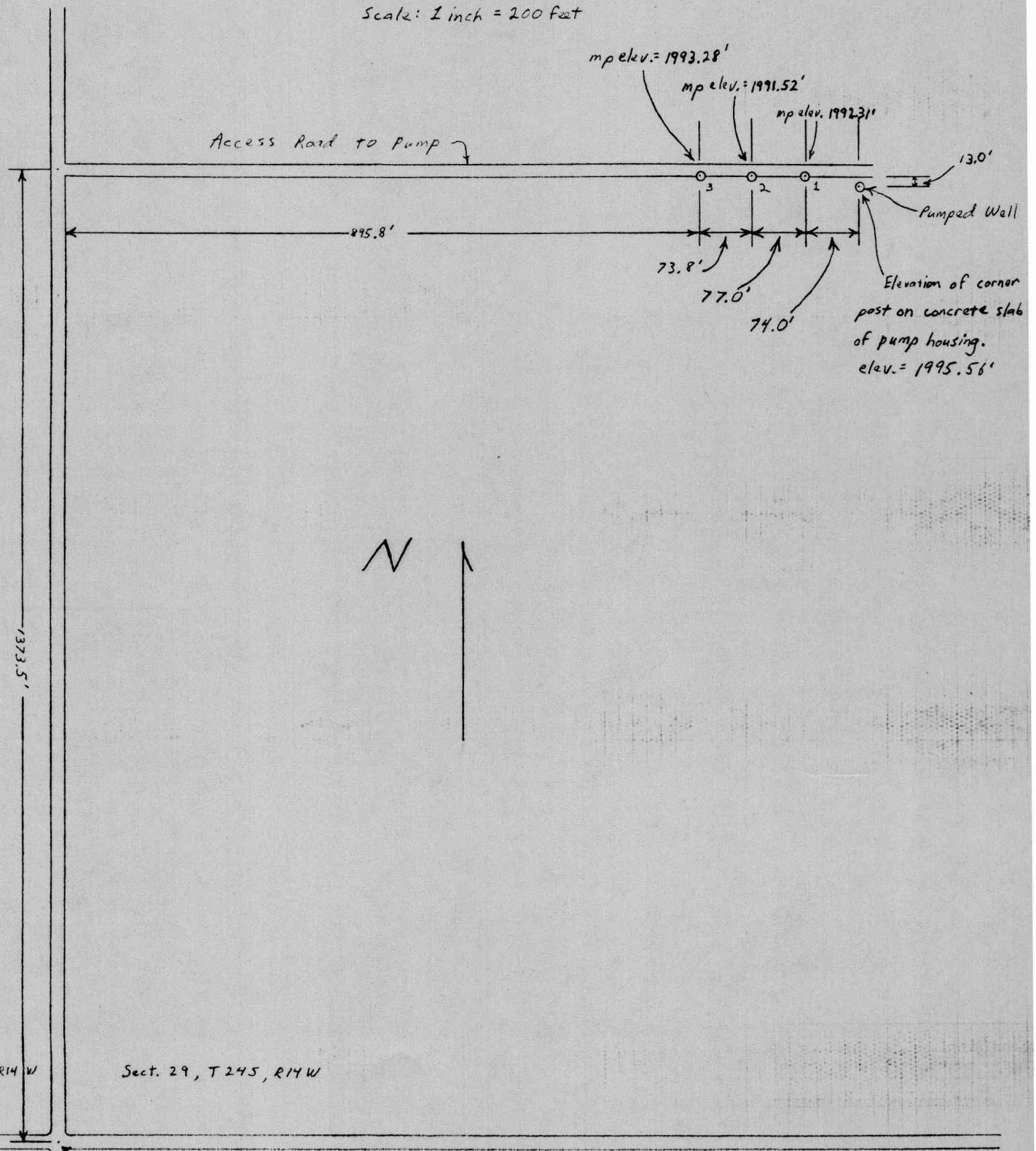


Fig. B-1

Geohydrology

The geology is typical of the region except that the quaternary dune sand deposition has apparently been altered, or possibly removed by the meandering of Rattlesnake Creek. There is a 60' bed of clastic material, generally Pleistocene in age, ranging from fine sand to medium gravel. The clastic material is moderately clay free, with only one significant clay being noted at 64' (see Appendix B-1). The original engineering sketch (Fig. B-2) indicates a clay unit at 96'. It is not known whether the clay was interpreted as bedrock. Reference to a bedrock map of the area (Fader and Stullken, 1978) indicates a possible total thickness of about 170' for the unconsolidated unit. Since a rotary drill was not available for this test, no attempt was made to find bedrock, which is probably the Kiowa Formation of the Lower Cretaceous. In fact, the pumping well may represent a partially penetrating well.

The unconsolidated sand and gravel units are overlain by about 30' of fine grained material, grading from a sandy loam to a sandy clay. These units appeared to be of low permeability, and at the time of drilling were of low moisture content. Initial umpumped water levels taken from the observation wells are above the base of the clay, indicating the possibility of semi-confined to confined conditions existing initially. This range of conditions is borne out by the data (see analysis of data), but there is no evidence of recharge from storage during the duration of the test, as might be expected from a saturated clay. From a geohydrological point of view, the area is generally more homogeneous in an aerial sense, than in a vertical sense.

Conducting the Pumptest

The test was conducted on a portion of aquifer which had not been previously pumped in the 1979 irrigation season and was, therefore, assumed to satisfy the condition of an initially horizontal free surface. No other pumping wells were known to exist within one mile of the well. The well was equipped with a flow meter which had operated in the previous year so that the well has a known history of a stable discharge. During the course of the test, the only significant deviation of discharge correlates with the operation of the end gun (see Introduction).

During the course of the test weather conditions were stable. Thus, even though the barometric efficiency of the aquifer was unknown, it is probably an insignificant factor. The humidity and temperature were moderate to high during the test with a wind which started from the northwest, shifted to the south about 11:00 a.m. and then diminished in the afternoon. Corn was being grown in the field and was highly stressed with respect to moisture. The soil was very deficient with respect to moisture to a depth of at least three feet. This was discovered in the process of setting tensiometers in the same field. These conditions are important to note, in that the water derived from he aquifer is applied directly to the surface above the aquifer, a practice usually avoided in aquifer pump tests. Given these antecedent soil moisture conditions, crop conditions and meteorologic conditions, it was felt that no significant recharge would occur from seepage. The short duration of the test served to strengthen this assumption and, in fact, no recharge features were noted in the plotted data.

When the pump became disabled, a recovery test was begun. A surge of water was noted entering the well from the irrigation unit, as no check valve was installed. This may have influenced the initial rapid recovery noted in the first observation well, at which recovery observations were made. No observations of water levels were made at any time in the pumping well except at the beginning. While this makes some generalized computations such as specific discharge of the well impossible, it does not reduce the value of this test. The well was checked for drawdowns at different discharges (see Fig. B-2) when constructed, and since the well receives good maintenance, these have probably not changed significantly.

Analysis of Data

Data analysis was done by traditional straight line formula and curve matching techniques, as well as by a more novel computer method (see Methods of Analysis for outlines of the methods). The results of the methods will be discussed here.

Observing the Jacob-Cooper solutions in Appendix B-3, we note the following results.

Table B-1a

Aquifer Parameters Computed from Late Time Values

Obs. Well No.	1	2	3
T (gpd/ft)	71900	80600	112000
S (unitless)	.025	.027	.007

T_{av} = 88200 S_{av} = .020

Table B-1b

Aquifer Parameters Computed from Early Time Values

Obs. Well. No.	1	2	3
T (gpd/ft)	117500	119700	241000
S (unitless)	.017	.025	.002

The values of T decrease as time passes while the values of S tend to increase. The latter fact implies a reduction of confinement as pumping progresses. The distribution of S may represent an actual inhomogeneity in the aquifer, or it may indicate that well #3 is simply not yet in an unconfined condition. If time progressed far enough, this value may have approached the values at wells #1 and #2. The change in T between early and late time may simply represent the decline in elastic storage of the aquifer as confinement diminishes. The values for T_{av} and S_{av} may be high. If the test had continued, values may have uniformly approached T_{av} = 76300 and S_{av} = .026, which are the averages of wells #1 and #2. Very long pumping may have produced S values as great as 0.2.

Analysis by the Theis recovery method (Appendix B-3) showed values of T ranging from 62200 gpd/ft to 68500 gpd/ft depending upon interpolation of the straight line. These values are somewhat lower than the one computed above. These values may be artificially low due to the rapid slug recharge which entered the pumping well after shut down (see text). A large recovery took place in a short period of time relative to the length of the recovery test. No recovery tests were run on wells #2 and #3, so the extent of the anomaly is unknown. The computed value of S/S" = 1.05 indicates only a 5% difference between the pumping storage coefficient and the recharge coefficient.

For the Theis Curve Fit method (Appendix B-3) we note the following tabulated results:

Table B-3

Theis Visual Curve Fit Results for Late Time

Obs. Well No.	1	2	3
T (gpd/ft)	70250	73500	106300
S (unitless)	.023	.030	.007

Table B-4

Theis Visual Curve Fit Results for Early Time

Obs. Well No.	1	2	3
T (gpd/ft)	168300	336600	207200
S (unitless)	.008	.034	.003

Again, the reduction in S as time progresses generally holds, but well #2 upsets this trend. The observations made for the Jacobs-Cooper analysis generally hold here except that estimates for long-term average T and S vary slightly: T = 7200, S = .027. The composite plot for the observation wells lends reinforcement to the hypothesis of relative homogeneity of aquifer parameters at large values of time. All three curves give the impression of assymtotically approaching a single value at large values of t/r^2.

The values obtained for T and S by computer regression are shown below (Table B-5) along with the standard deviation from the theoretical curve.

Table B-5

Obs. Well No.	Transmissivity (gpd/ft)	Storage Coeff.	Std. Deviation
1	79400	.018	.14
2	70200	.03	.03
3	134500	.005	.13

The low standard deviation for observation well #2 indicates the most acceptable fit of the group, but comparison of the machine fitted data with other processes indicates that all of the "best fit" T and S pairs are within reason. These data are tabulated in Table B-6.

Table B-6

Late Time T and S Values by Three Methods

Obs. Well No.	1		2		3	
Theis (visual)	70250	.023	73450	.030	106300	.007
Theis (computer)	79400	.018	70200	.030	134500	.005
Jacob-Cooper	71900	.025	80600	.027	112000	.007

Note the apparent discrepancies between observation wells #1 and #2 and observation well #3. From a simplistic point of view, this may be interpreted as an anisotropy of the aquifer. A slightly more sophistocated view point is that due to the short duration of the test, a uniform condition of confinement was not achieved at all observation points within the aquifer. This arguement is most readily defendable from the point of changes in storage coefficient values. The average S value for wells 1 and 2 is .025, while the S value at well 3 is .006, a difference of a factor of 4. Examination of the composite plot of s vs t/r^2 for the data (Appendix B-3) indicates that for very large values of time, all curves will probably approach a single curve as a limiting value. Thus, if the test had continued, S and T for all three

locations would have approached the same value.

Examination of the Theis curve matching plots and the Jacob-Cooper plots (Appendix B-3) shows an apparent inflection point in the region .001 $\leq$ .01. The classic interpretation of this inflection point is a barrier boundary. Examination of the computations for the Theis curve matches and the Jacobs-Cooper solutions give differences in T of a factor of 2 or 3 across the inflection point. Thus, T is larger before the inflection than it is afterwards. The location of the boundary or its nature is unknown, except that it is a barrier. This point of ignorance demonstrates the need for a two-dimensional observation well array whenever possible.

The conclusion of this aquifer test analysis is that the local aquifer near the test well is probably in a semi-confined state when in an undisturbed state, but as pumping progresses, expecially towards large values of time, the aquifer tends to the unconfined state with T and S values of 75000 gpd/ft and .025 respectively. There is probably some barrier boundary actively influencing the T value, but its location and nature is unknown.

Appendix B-1

Drillers Logs

ne 24 ANDERSEN & DARLING Phone 705

JAMESTOWN, KANSAS

—Log Of Test Well—

Date of Test 2/20/57

tomer J.H.Sparks Address Macksville

ation 4 miles east 1½ south

Well 29-21-14 Static Water Level 20ft.

6	soil
28	red clay R.D. Rock
34	gray clay
40	yellow sand
46	medium fine sand
60	coarse gravel
64	green clay
80	medium gray sand and gravel
95	medium to coarse gravel

Augered Test Hole, T24-R14W-29c2. STAFFORD COUNTY, KANSAS, elev: 1192.35±1' drilled 27 March 1979; augered depth 72'; finished depth 71'. 75' from irrigation well on access road. Screened with 3' well point, 21' of slotted 1¼" steel pipe, and 40' of slotted 2½" PVC. Gravel packed with fine gravel. Took about 8 gpm. Observation well #1.

Description	Depth	Thickness
Loam, brown, sandy	4.5	4.5
Silt, brownish gray, sandy with a sandy clay stringer	6	1.5
Silt, reddish brown, sandy, thin gray stringers	6.5	.5
Clay, gray, hard, dry	7	.5
Silt, reddish brown, sandy, with thin black silt stringers	8	1
Silt, reddish gray, sandy, blocky, gray silt stringers	14	6
Clay, reddish brown, sandy, tight	16	2
Clay, pinkish tan, sandy, damp	20	4
Clay, grayish brown, sandy, damp	25	5
Clay, tan, blocky	27	2
No return for rest of hole; probably sand	72	45

Fitted with a Stevens Water Level Recorder, W233160

Date	Water Level (bmp)
30 Apr 79	27.0 ft
14 May 79	26.55 ft
21 May 79	27.23 ft
31 May 79	27.26 ft
15 June 79	26.87 ft
20 June 79	27.16 ft

Augered Test Hole, T24-R14-29c3, STAFFORD COUNTY, KANSAS. Elev: 1991.52±1'
Drilled 28 March 1979; augered depth 76'; finished depth 62'.
151' from irrigation well on access road. Screened with 3' well point, 42' slotted 1¼" steel, 20' blank 1¼" steel. Gravel packed with fine gravel. Took about 5 gpm. Observation Well #2.

This well was augered too fast to get a good log, although there seemed to be more clay at depth. Water at ≈24'.

Date	Water Level (bmp)
29 March 1979	24.0'
20 June 1979	26.19'

Augered Test Hole, T24-R14W-29c3, STAFFORD COUNTY, KANSAS. Elev: 1993.28±1'
Drilled 28 March, 1979; augered depth 80'; finished depth 76'.
226' from irrigation well on access road. Screened with 3' well point, 52' of slotted 1¼" steel and 21' of blank 1¼" steel. Gravel packed with fine gravel and sand. Took about 8 gpm. Observation Well #3.

Description	Thickness	Depth
Loam, dark brown, sandy	2½'	2½'
Clay, dark brown, blocky	2½'	5
Clay, light brown, blocky	5	10
Silt, reddish brown, sandy	5	15
Silt, pinkish gray, sandy	3	18
Sand, fine, pinkish, silty	2	20
Silt, pinkish gray, sandy	12	32
Sand, fine to coarse, and fine to medium gravel, quartz arkose, some clay lenses	44	76

Date	Water Level (bmp)
20 June 1979	27.82'

Appendix B-2

Time-Drawdown and

Time-Recovery Data

County : Stafford near Dillwyn
Location: T29 - R14W Sec 29 c. SW/4

Observation well no. 1 1 of 2 pages
Pumped well no. R.D. Bookstore

Average Q 705 gpm r = 75.17 ft. r^2 = 5620.53

Date	Hour	t (min)	t' (days)	t/r^2 (min/ft²)	Depth to water	s (unadjusted)	Adjustment Δs	s' (adjusted)	Q (gpm)	Remarks
6/20/79	9:55 a	0	0	—	27.16	0	0			Engine drives pump through 6:5 reduction
		1	6.25×10^{-4}	1.77×10^{-4}	27.33	.17				
		2	2.5×10^{-3}	3.54×10^{-4}	27.53	.37				
		3	2.08×10^{-3}	5.31×10^{-4}	—	—				
		4	2.78×10^{-3}	7.08×10^{-4}	27.74	.58				
	9:00 a	5	3.47×10^{-3}	8.85×10^{-4}	27.84	.68				
		6	4.17×10^{-3}	1.06×10^{-3}	27.91	.75				
		7	4.86×10^{-3}	1.24×10^{-3}	27.98	.82				
		8	5.56×10^{-3}	1.42×10^{-3}	28.02	.86				
		9	6.25×10^{-3}	1.59×10^{-3}	28.05	.89				
	9:05 a	10	6.94×10^{-3}	1.77×10^{-3}	27.90	.74			690	End gun not operating at start of test
		12.5	8.68×10^{-3}	2.21×10^{-3}	28.23	1.07			690	
	9:10 a	15	1.04×10^{-2}	2.65×10^{-3}	28.32	1.16				
		17.5	1.22×10^{-2}	3.10×10^{-3}	—	—				
	9:15 a	20	1.39×10^{-2}	3.54×10^{-3}	28.50	1.34				
	"	22.5	1.56×10^{-2}	3.98×10^{-3}	28.53	1.37				
	9:20 a	25	1.74×10^{-2}	4.42×10^{-3}	28.68	1.52				
		27.5	1.91×10^{-2}	4.87×10^{-3}	28.74	1.58			690	
	9:25 a	30	2.08×10^{-2}	5.31×10^{-3}	28.77	1.61				
		32.5	2.26×10^{-2}	5.75×10^{-3}	28.86	1.70				
	9:30 a	35	2.43×10^{-2}	6.20×10^{-3}	28.93	1.77				
		37.5	2.60×10^{-2}	6.64×10^{-3}	28.96	1.80				
	9:35 a	40	2.78×10^{-2}	7.08×10^{-3}	29.04	1.88				
	9:40 a	45	3.13×10^{-2}	7.96×10^{-3}	29.12	1.96			695	
6/20/79	9:45 a	50	3.47×10^{-2}	8.85×10^{-3}	29.21	2.05				

Figure 3.—Continued.

County :_____ Observation well no._____ 2 of 2 pages

Location:_____ Pumped well no._____

Average Q_____ gpm r=_____ft. r^2=_____

Date	Hour	t (min)	t′ (min)	t/r^2 min/ft^2	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/20/79	9:50a	58		1.03×10^{-2}	29.32	2.16				
	1:55a	60		1.06×10^{-2}	29.32	2.16				
	0:00a	65		1.15×10^{-2}	29.46	2.30				
	10:05a	70		1.24×10^{-2}	29.54	2.38				
	10:10a	75		1.33×10^{-2}	29.58	2.42			690	
	10:15a	80		1.42×10^{-2}	29.66	2.50				
	10:20a	85		1.50×10^{-2}	29.77	2.61				
	10:25a	90		1.59×10^{-2}	29.77	2.61				
	10:30a	95		1.68×10^{-2}	29.87	2.71			730	End gun started to operate
	10:35a	100		1.77×10^{-2}	29.92	2.76				
	11:00a	125		2.21×10^{-2}	30.18	3.02				
	11:25a	150		2.65×10^{-2}	30.45	3.29				
	11:50a	175		3.10×10^{-2}	30.48	3.32				
	11:55a	180		3.19×10^{-2}	30.60	3.44				
	12:19p	204		3.61×10^{-2}	30.76	3.60				
	12:39p	224		3.96×10^{-2}	30.87	3.71				
	1:02p	247		4.37×10^{-2}	31.00	3.84				
	1:34p	279		4.94×10^{-2}	31.14	3.98				
	1:53p	298		5.27×10^{-2}	31.21	4.05				
	2:17p	322		5.7×10^{-2}	31.30	4.14				
	2:43p	348		6.16×10^{-2}	31.39	4.23			720	@ 2025 engine rpm
6/20/79	2:52p	357			—	—			—	pump stopped. started taking recovery measurements

Figure 3.—Continued.

County : Stafford near Dillwyn — Observation well no. 2 — 1 of 2 pages
Location: T24 - R14W Sec 29 c. SW/4 — Pumped well no. R. D. Bookstore

Average Q 705 gpm r = 151.56 ft. r^2 = 22970.43

Date	Hour	t (min)	t' (day)	t/r^2 (min/ft²)	Depth to water	s (unadjusted)	Adjustment Δs	s' (adjusted)	Q (gpm)	Remarks
6/20/79	8.55AM	0	0	—	26.19	0				
	8.56	1	6.94×10^{-4}	4.35×10^{-5}	26.19	0				
	8.57	2	[illegible]	[illegible]	26.21	0.02				
	8.58	3	[illegible]	1.31×10^{-4}	26.23	0.04				
	8.59	4	[illegible]	1.74×10^{-4}	26.23	0.04				
	9.00	5	[illegible]	2.18×10^{-4}	26.23	0.04				
	9.01	6	[illegible]	[illegible]	26.23	0.04				
	9.02	7	[illegible]	3.05×10^{-4}	26.25	0.06				
	9.03	8	[illegible]	3.49×10^{-4}	26.27	0.08				
	9.04	9	[illegible]	3.92×10^{-4}	26.28	0.09				
	9.05	10	[illegible]	4.35×10^{-4}	26.29	0.10				
	9:07:30	12.50	[illegible]	5.44×10^{-4}	26.32	0.13				
	9.10	15	[illegible]	6.53×10^{-4}	26.34	0.15				
	9:12:30	17.50	[illegible]	7.62×10^{-4}	26.37	0.18				
	9.15	20	[illegible]	8.71×10^{-4}	26.39	0.20				
	9:17:30	22.50	[illegible]	9.80×10^{-4}	26.41	0.22				
	9.20	25	[illegible]	1.09×10^{-3}	26.44	0.25				
	9:22:30	27.50	[illegible]	1.12×10^{-3}	26.47	0.28				
	9.25	30	[illegible]	1.31×10^{-3}	26.50	0.31				
	9:27:30	32.50	[illegible]	1.42×10^{-3}	26.53	0.34				
	9.30	35	[illegible]	1.52×10^{-3}	26.57	0.38				
	9:32:30	37.50	[illegible]	1.63×10^{-3}	26.60	0.41				
	9.35	40	[illegible]	1.74×10^{-3}	26.62	0.43				
	9.40	45	[illegible]	1.96×10^{-3}	26.69	0.50				
6/20/79	9.45	50	[illegible]	2.18×10^{-3}	26.74	0.55				

Figure 3.—Continued.

County :_____ Observation well no._____ 2 of 2 pages

Location: _____ Pumped well no. _____

Average Q_____ gpm r=_____ft. r^2=_____

Date	Hour	t (min)	t′ (min)	t/r^2 (min/ft^2) t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/20/79	9.50	55		2.39×10^{-3}	26.79	0.60				
	9.55	60		2.61×10^{-3}	26.84	0.65				
	10.00	65		2.83×10^{-3}	26.90	0.71				
	10.05	70		3.05×10^{-3}	26.96	0.77				
	10.10	75		3.27×10^{-3}	27.02	0.83				
	10.15	80		3.48×10^{-3}	27.07	0.88				
	10.20	85		3.70×10^{-3}	27.12	0.93				
	10.25	90		3.92×10^{-3}	27.16	0.97				
	10.30	95		4.14×10^{-3}	27.22	1.03				
	10.35	100		4.35×10^{-3}	27.26	1.07				
	11.00	125		5.44×10^{-3}	27.44	1.25				
	11.25	150		6.53×10^{-3}	27.61	1.42				
	11.50	175		7.62×10^{-3}	27.78	1.59				
	12.15 p.m.	200		8.71×10^{-3}	27.89	1.70				
	12.40	225		9.80×10^{-3}	28.03	1.86				
	1.05	250		1.09×10^{-2}	28.12	1.93				
	1.30	275		1.20×10^{-2}	28.23	2.04				
	1.55	300		1.31×10^{-2}	28.35	2.16				
	2.23	328		1.43×10^{-2}	—	—				
6/20/79	2.45	350		1.5×10^{-2}	28.60	2.41				

Figure 3.—Continued.

County : Stafford near Dillwyn
Location: T24 - R14W - Sec 29 c. SW/4

Observation well no. 3 1 of 2 pages
Pumped well no. R.D. Bookstore

Average Q 705 gpm r = 226.37 ft. r^2 = 51243.38

Date	Hour	t (min)	t' (day)	t/r² (min/ft²) t/t'	Depth to water	s (unadjusted)	Adjustment Δs	s' (adjusted)	Q (gpm)	Remarks
6/20/79	8:55 a	0	0	—	27.82	0				
		1	6.94×10^{-4}	1.95×10^{-5}	—	—				
		2	1.39×10^{-3}	3.9×10^{-5}	28.10	0.28				
		3	2.08×10^{-3}	5.8×10^{-5}	—	—				
		4	2.78×10^{-3}	7.81×10^{-5}	28.18	0.36				
	9:00 a	5	[illegible]	9.76×10^{-5}	27.80	-0.02				
		6	[illegible]	1.17×10^{-4}	28.33	0.51				
		7	[illegible]	1.36×10^{-4}	—	—				
		8	[illegible]	1.56×10^{-4}	—	—				
		9	[illegible]	1.76×10^{-4}	—	—				
	9:05 a	10	[illegible]	1.95×10^{-4}	28.36	0.56				
		12.5	[illegible]	2.44×10^{-4}	28.42	0.60				
	9:09 a	14.0	[illegible]	2.73×10^{-4}	28.49	0.67				
		17.5	[illegible]	3.42×10^{-4}	28.38	0.56				
	9:15 a	20.0	[illegible]	3.90×10^{-4}	28.52	0.70				
		22.5	[illegible]	4.39×10^{-4}	28.55	0.73				
	9:20 a	25.0	[illegible]	4.88×10^{-4}	28.58	0.76				
		27.5	[illegible]	5.37×10^{-4}	28.62	0.80				
	9:25 a	30.0	[illegible]	5.85×10^{-4}	28.66	0.84				
		32.5	[illegible]	6.34×10^{-4}	28.67	0.85				
	9:30 a	35.0	2.43×10^{-2}	6.83×10^{-4}	28.70	0.88				
		37.5	[illegible]	7.32×10^{-4}	28.72	0.90				
	9:35 a	40.0	[illegible]	7.81×10^{-4}	28.75	0.93				
	9:40 a	45	3.13×10^{-2}	8.78×10^{-4}	28.80	0.98				
6/20/79	9:45 a	50	3.47×10^{-2}	9.76×10^{-4}	28.82	1.00				

Figure 3.—Continued.

County : _____ Observation well no. 3 2 of 2 pages

Location: _____ Pumped well no. _____

Average Q _____ gpm r = _____ ft. r^2 = _____

Date	Hour	t (min)	t′ (min)	t/r^2 (min/ft^2) t/t′	Depth to water	s (unadjusted)	Adjustment Δs	s′ (adjusted)	Q (gpm)	Remarks
6/20/79	9:50 a	55		1.07×10^{-3}	28.85	1.03				
	9:55 a	60		1.17×10^{-3}	28.90	1.08				
	10:00 a	65		1.27×10^{-3}	28.92	1.10				
	10:05 a	70		1.37×10^{-3}	28925	1.105				
	10:10 a	75		1.46×10^{-3}	28.92	1.10				
	10:17 30	82.5		1.61×10^{-3}	29.08	1.26				
	10:20 a	85		1.66×10^{-3}	29.11	1.29				
	10:25 a	90		1.76×10^{-3}	29.14	1.32				
	10:30 a	95		1.85×10^{-3}	29.21	1.39				
	10:35 a	100		1.95×10^{-3}	29.24	1.42				
	11:00 a	125		2.94×10^{-3}	29.39	1.57				
	11:25 a	150		2.93×10^{-3}	29.52	1.70				
	11:50 a	175		3.42×10^{-3}	29.63	1.81				
	12:15 p	200		3.90×10^{-3}	29.75	1.93				
	12:40 p	225		4.39×10^{-3}	29.85	2.03				
	1:09 p	254		4.96×10^{-3}	29.92	2.10				
	1:28 p	273		5.33×10^{-3}	29.97	2.15				
	2:00 p	305		5.95×10^{-3}	30.05	2.23				
	2:20 p	325		6.34×10^{-3}	30.10	2.28				
6/20/79	2:45 p	350		6.83×10^{-3}	30.18	2.36				

Figure 3.—Continued.

County : Stafford, near Dillwyn — Observation well no. 1 (recovery) 1 of 2 pages
Location: T24-R14W-Sec 29 c. SW/4 — Pumped well no. R.D. Bookstore

Average Q — gpm r = ft. r^2 =

Date	Hour	t_r (min)	t' (min)	t/t'	Depth to water	s_r (unadjusted)	Adjustment Δs	$s''_{(ft)}$ (adjusted)	Q (gpm)	Remarks
6/20/79	pm 2:52	(35') 0		0	31.39	0		4.73		pumping well stopped operation at this time.
	pm 3:02	10		3.67x10'	30.37	1.02		3.71		Slug of water from cent. pivot drained back when pump quit.
	3:05 p	13		2.53x10'	30.25	1.14		3.59		
	3:10 p	18		2.08x10'	30.14	1.25		3.48		
	3:15 p	23		1.65x10'	30.04	1.35		3.38		
	3:23 p	31		1.25x10'	29.91	1.48		3.25		
	3:29 p	32		1.22x10'	29.89	1.50		3.23		
	3:26 p	34		1.15x10'	29.87	1.52		3.21		
	3:30 p	38		1.04x10'	29.80	1.59		3.14		
	3:35 p	43		9.3x10°	29.71	1.68		3.05		
	3:40 p	48		8.44x10°	29.64	1.75		2.98		
	3:45 p	53		7.91x10°	29.56	1.83		2.90		
	3:50 p	58		7.16x10°	29.49	1.90		2.83		
	3:57 p	65		6.49x10°	29.40	1.99		2.74		
	4:00 p	68		6.25x10°	29.36	2.03		2.70		
	4:05 p	73		5.89x10°	29.28	2.11		2.62		
	4:10 p	78		5.58x10°	29.21	2.18		2.55		
	4:15 p	83		5.30x10°	29.11	2.28		2.45		
	4:21 p	89		5.01x10°	29.06	2.33		1.90		
	4:25 p	93		4.84x10°	29.00	2.39		1.84		
	4:30 p	98		4.64x10°	28.96	2.43		1.80		
	4:35 p	103		4.49x10°	28.91	2.48		1.75		
	4:40 p	108		4.31x10°	28.87	2.52		1.71		
	4:45 p	113		4.16x10°	28.82	2.57		1.66		
	4:50 p	118		4.03x10°	28.79	2.60		1.63		

Figure 3.—Continued.

County : Stafford, near Dillwyn
Location: T24-R14W- Sec 29 c. SW/4

Observation well no. 1 (recovery) 2 of 2 pages
Pumped well no. R.D. Bookstore

Average Q_____ gpm r=_____ ft. r^2=_____

Date	Hour	t_r (min)	t' (min)	t/t'	Depth to water	s_r/s (unadjusted)	Adjustment Δs	s'' (adjusted)	Q (gpm)	Remarks
6/20/79	4:55 p	123	0	3.90×10⁶	28.74	2.65/0		1.58		pump resumed operation recovery stopped
	5:00 p	128	5		29.58	0.84				
	5:05 p	133	10		29.83	1.09				
	5:10 p	138	15		30.00	1.26				
	5:15 p	143	20		30.14	1.40				
	5:20 p	148	25		30.24	1.50				
	5:25 p	153	30		30.33	1.59				stopped taking measurements.

Figure 3.—Continued.

Appendix B-3

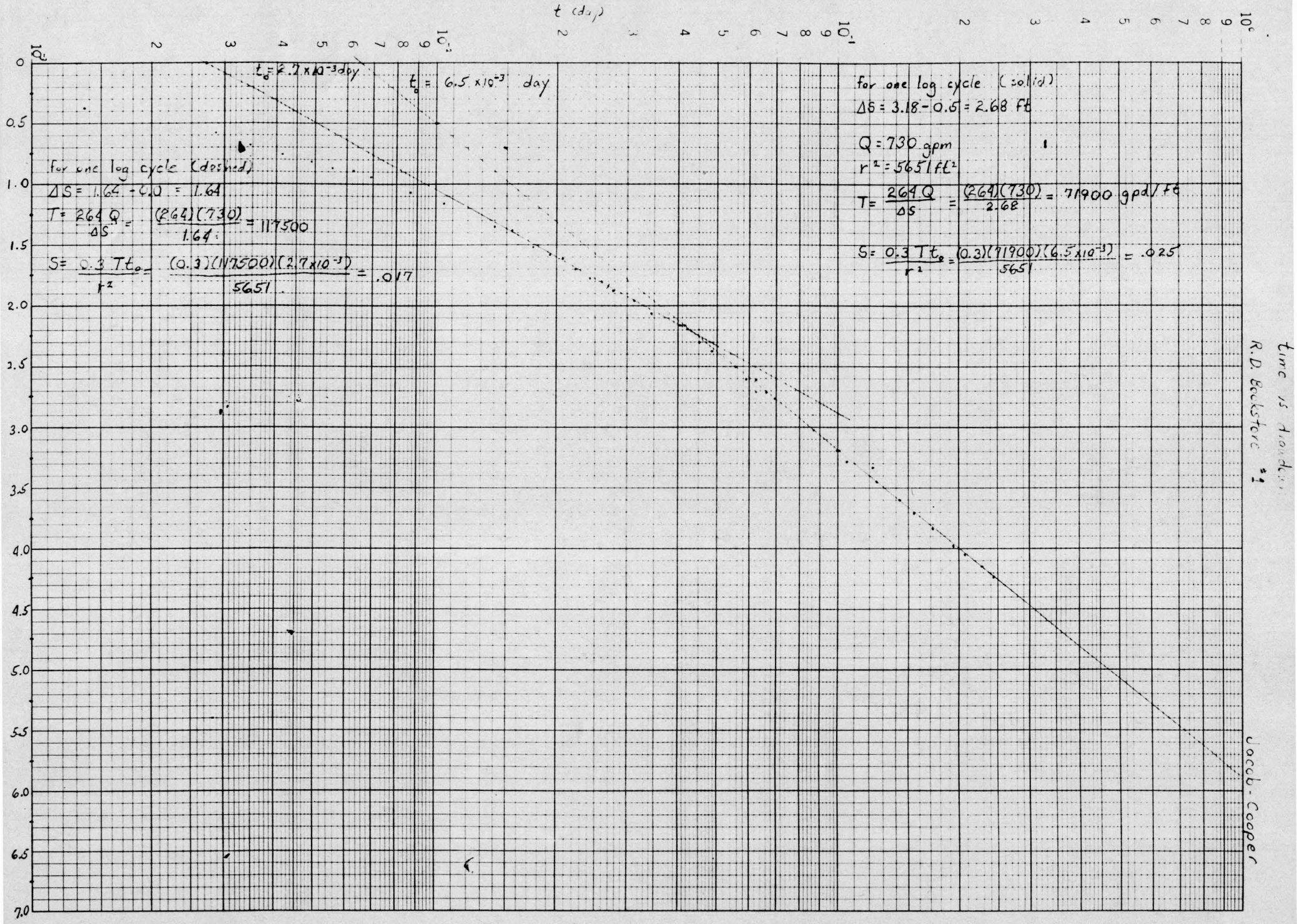
Jacob-Cooper Method

Theis Recovery Method

Theis Curve Match Method

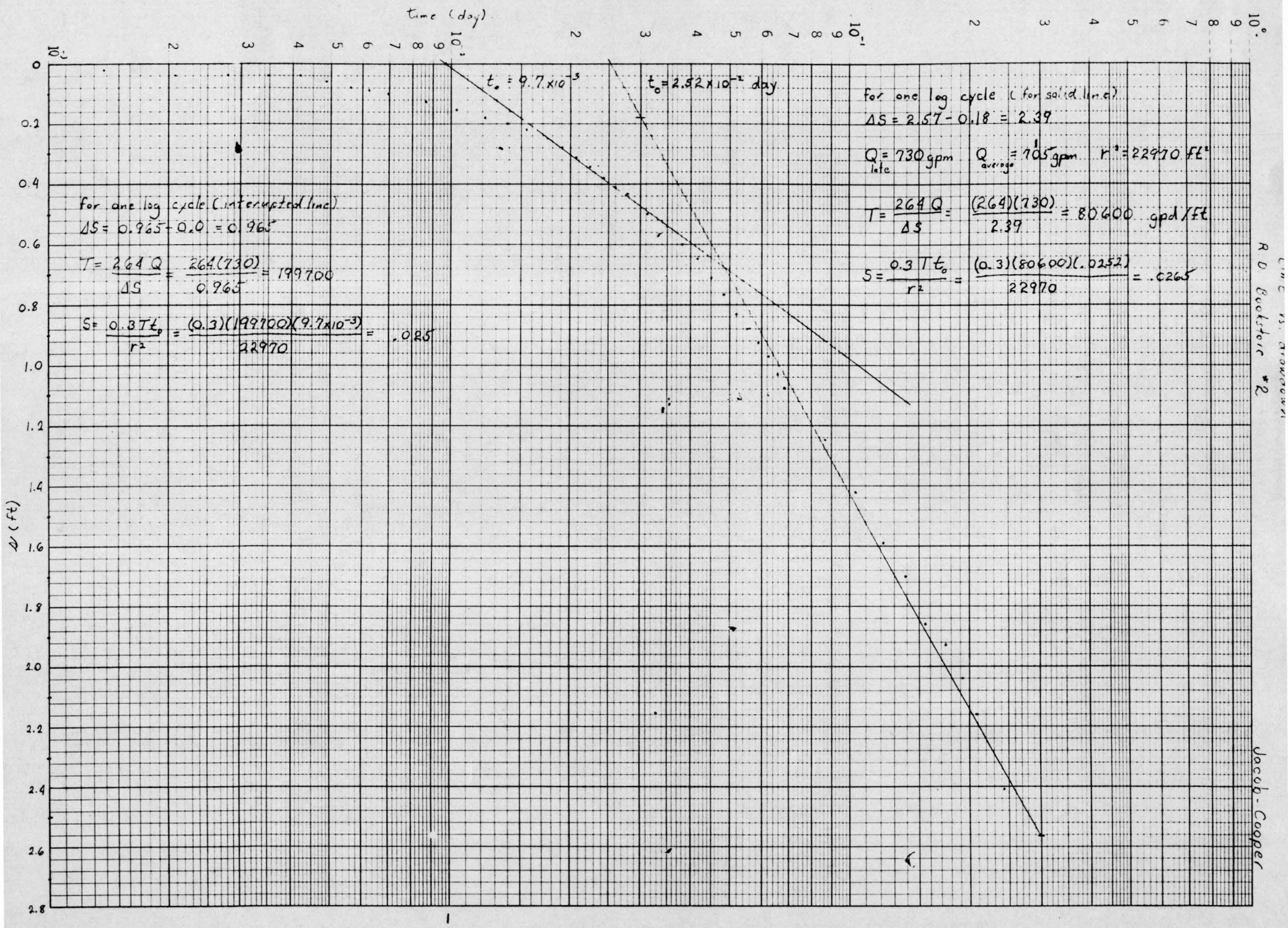
K&E 10 X 10 TO 5 CYCLES LOGARITHMIC
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 5490



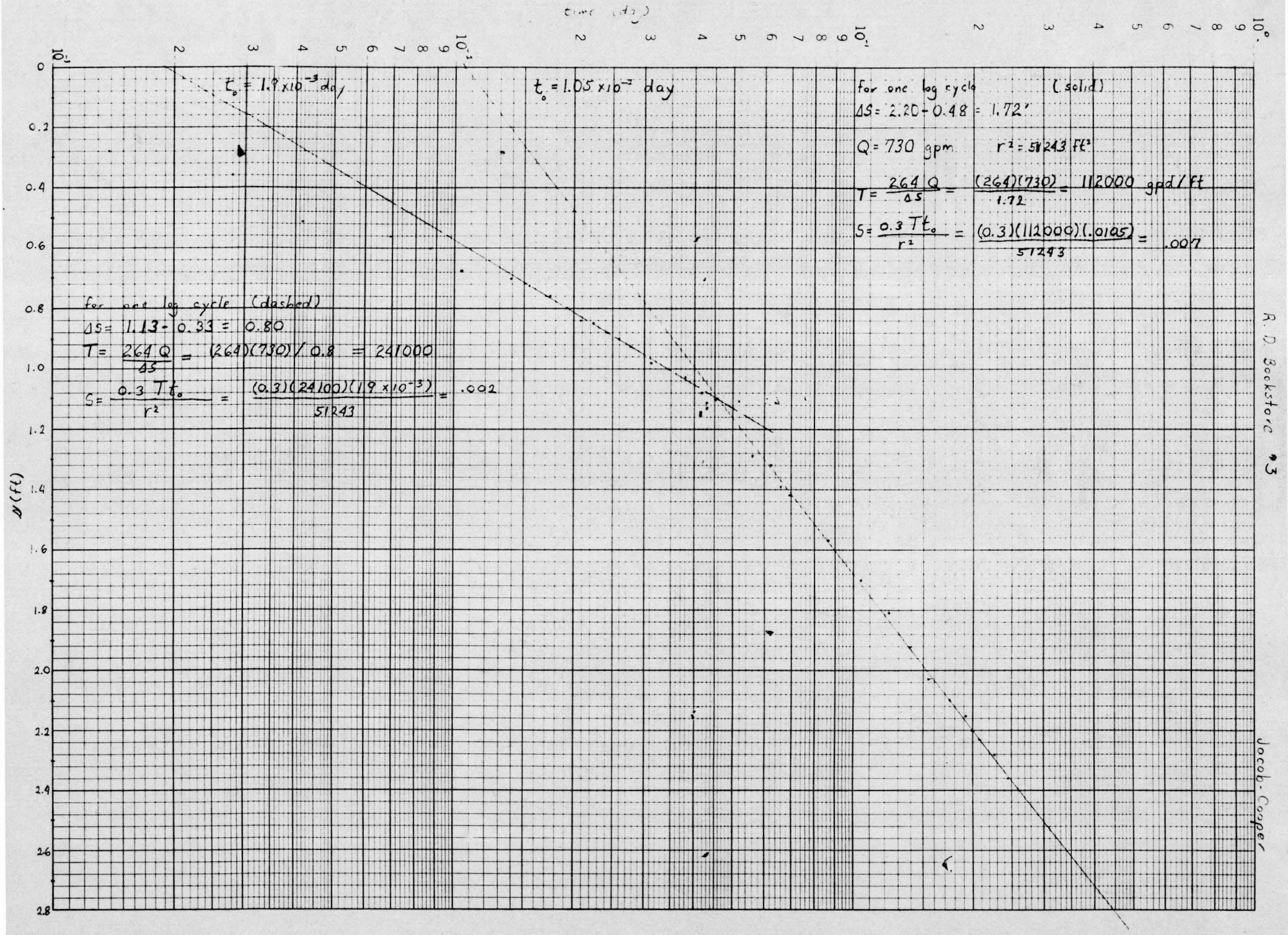
time vs drawdown
R.D. Beckstrom #1
Jacob-Cooper

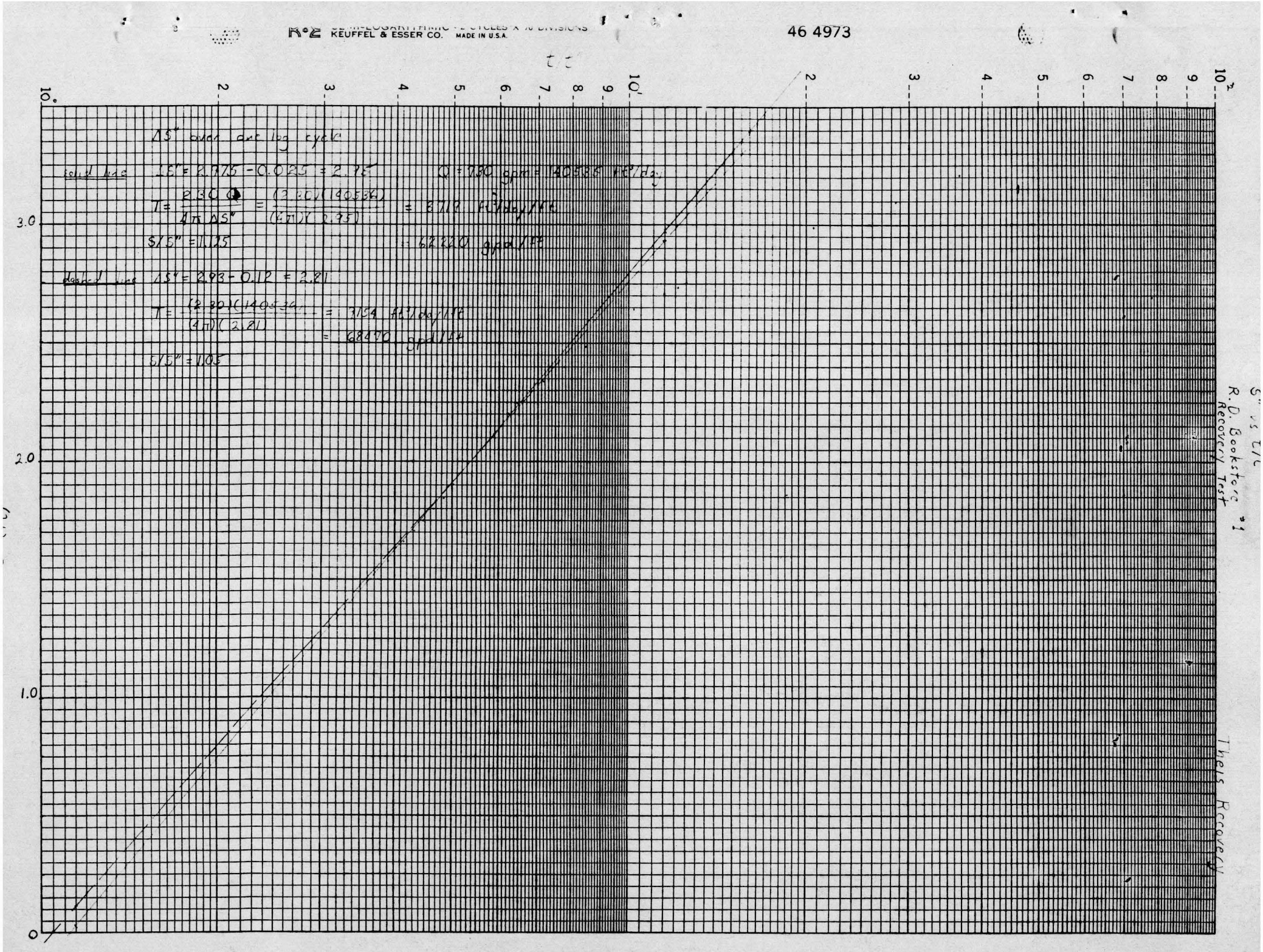
KEUFFEL & ESSER CO MADE IN U.S.A.



KE KEUFFEL & ESSER CO MADE IN USA

46 5490

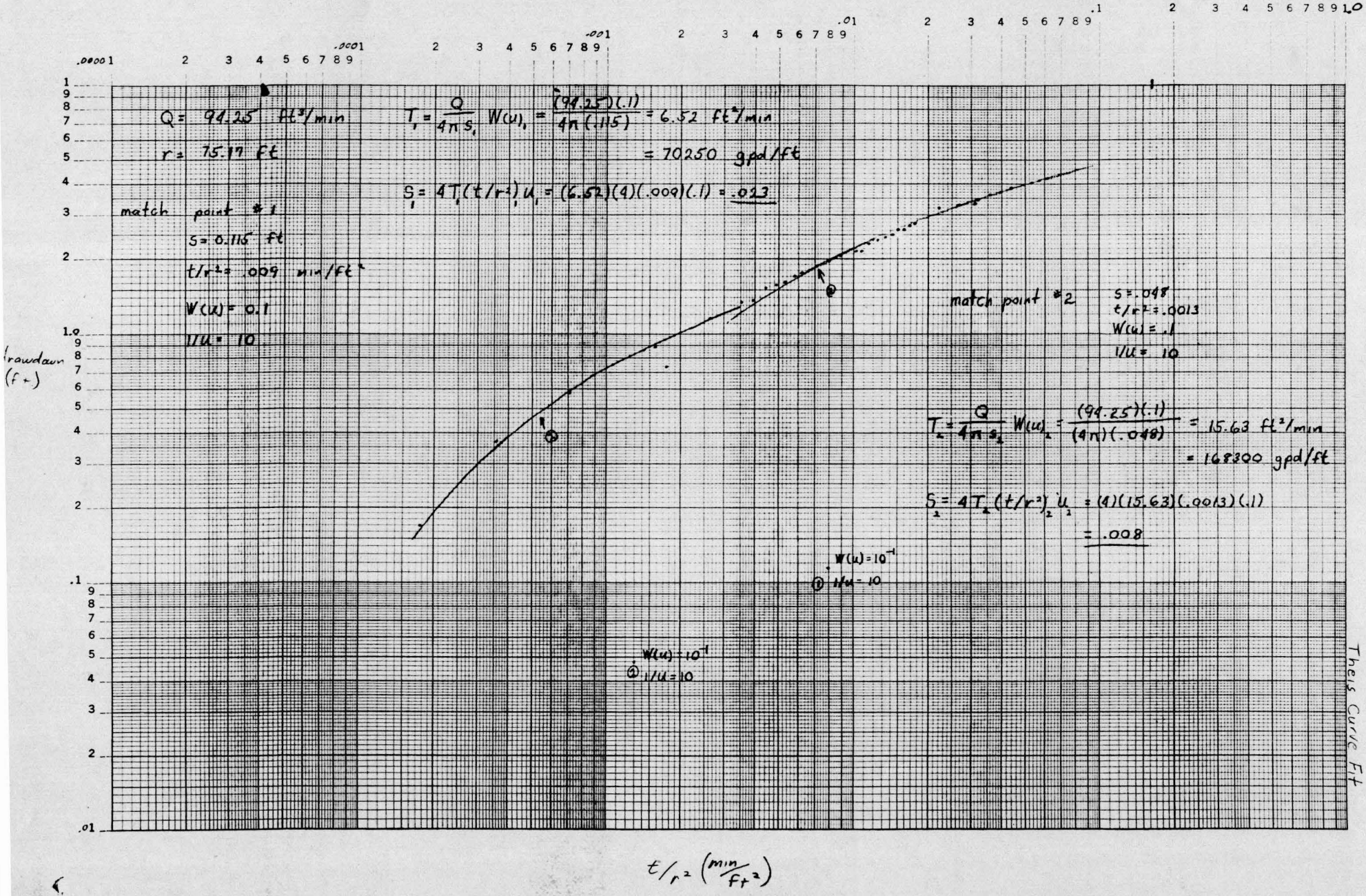




K+E SEMI-LOGARITHMIC 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 4973
t/t'
10°
2
3
4
5
6
7
8
9
10¹
10²
3.0
2.0
1.0
0
ΔS" over one log cycle
solid line ΔS" = 2.775 − 0.025 = 2.75
Q = 730 gpm = 140535 ft³/day
T = 2.30 Q / 4π ΔS" = (2.30)(140536) / (4π)(2.75) = 8717 ft²/day/ft
S/S" = 1.125
= 62220 gpd/ft
dashed line ΔS" = 2.93 − 0.12 = 2.81
T = (2.30)(140536) / (4π)(2.81) = 7154 ft²/day/ft
= 68470 gpd/ft
S/S" = 1.05
S" vs t/t
R.D. Bookstore #1
Recovery Test
Theis Recovery

KEUFFEL & ESSER CO. MADE IN U.S.A.

Well # 1

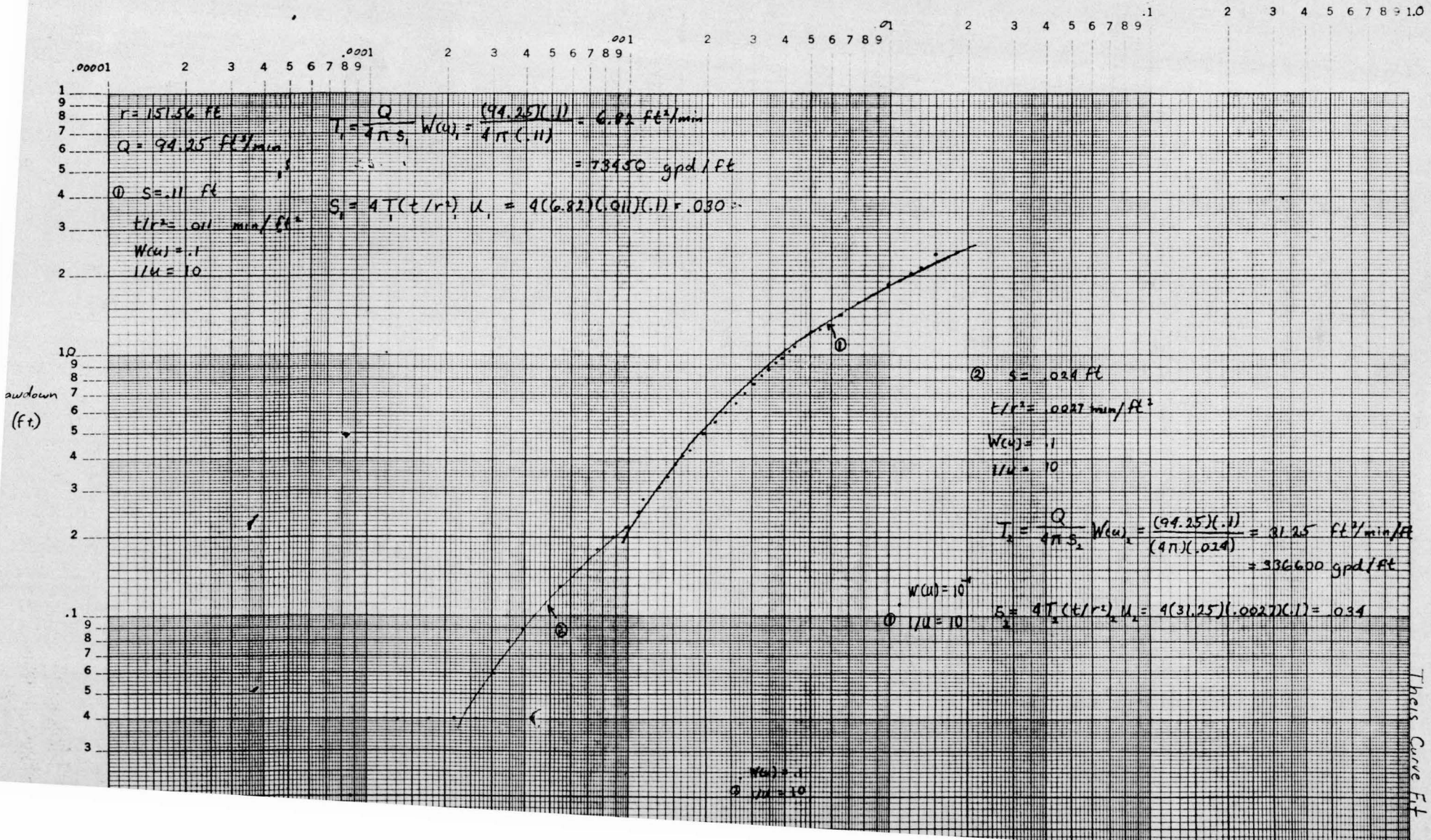


R. D. Bookstore #1

K+E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7522

Well # 2



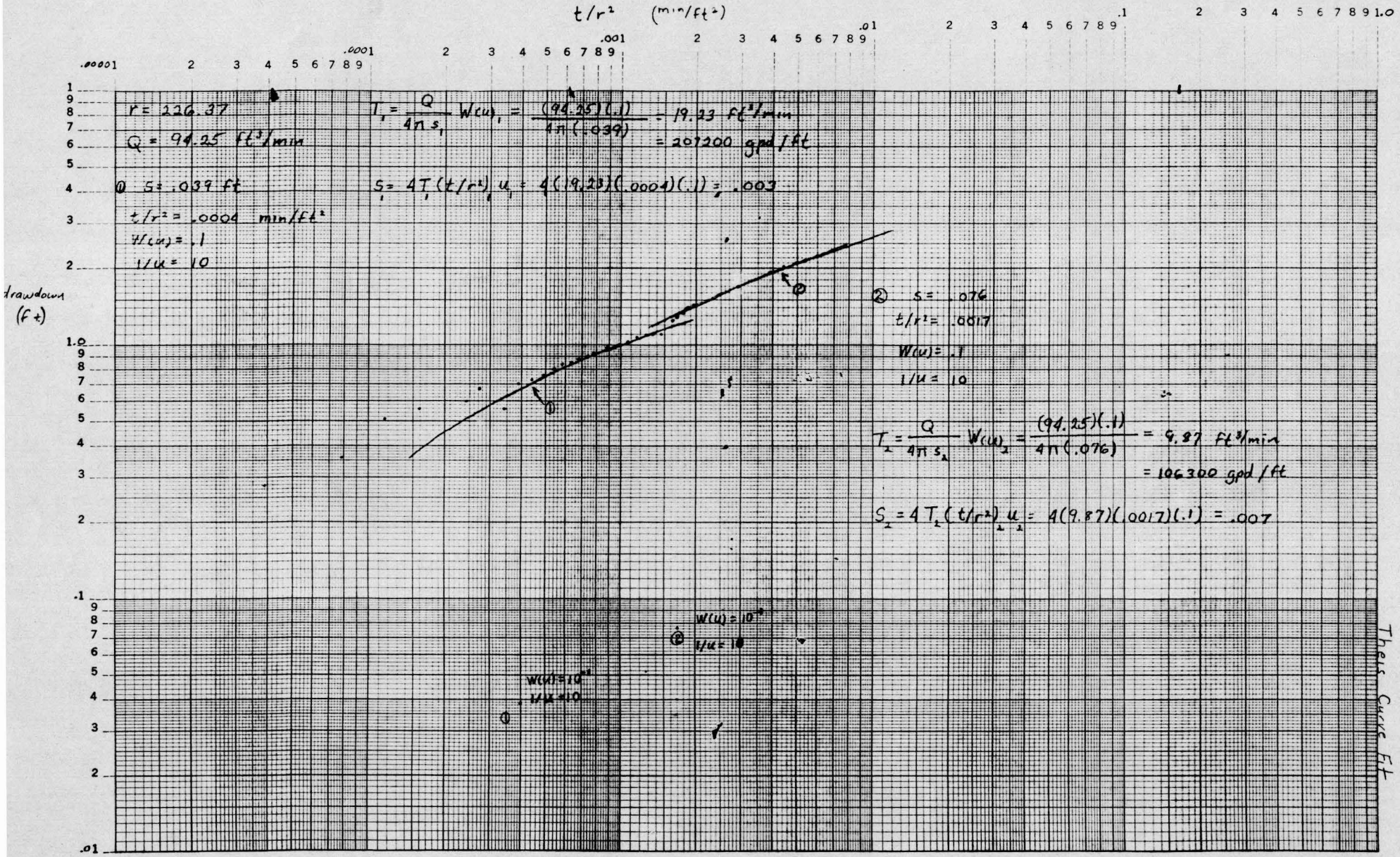
S vs. t/r²

R.D. Bookstore #2

Theis Curve Fit

K&E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 7522

Well #3

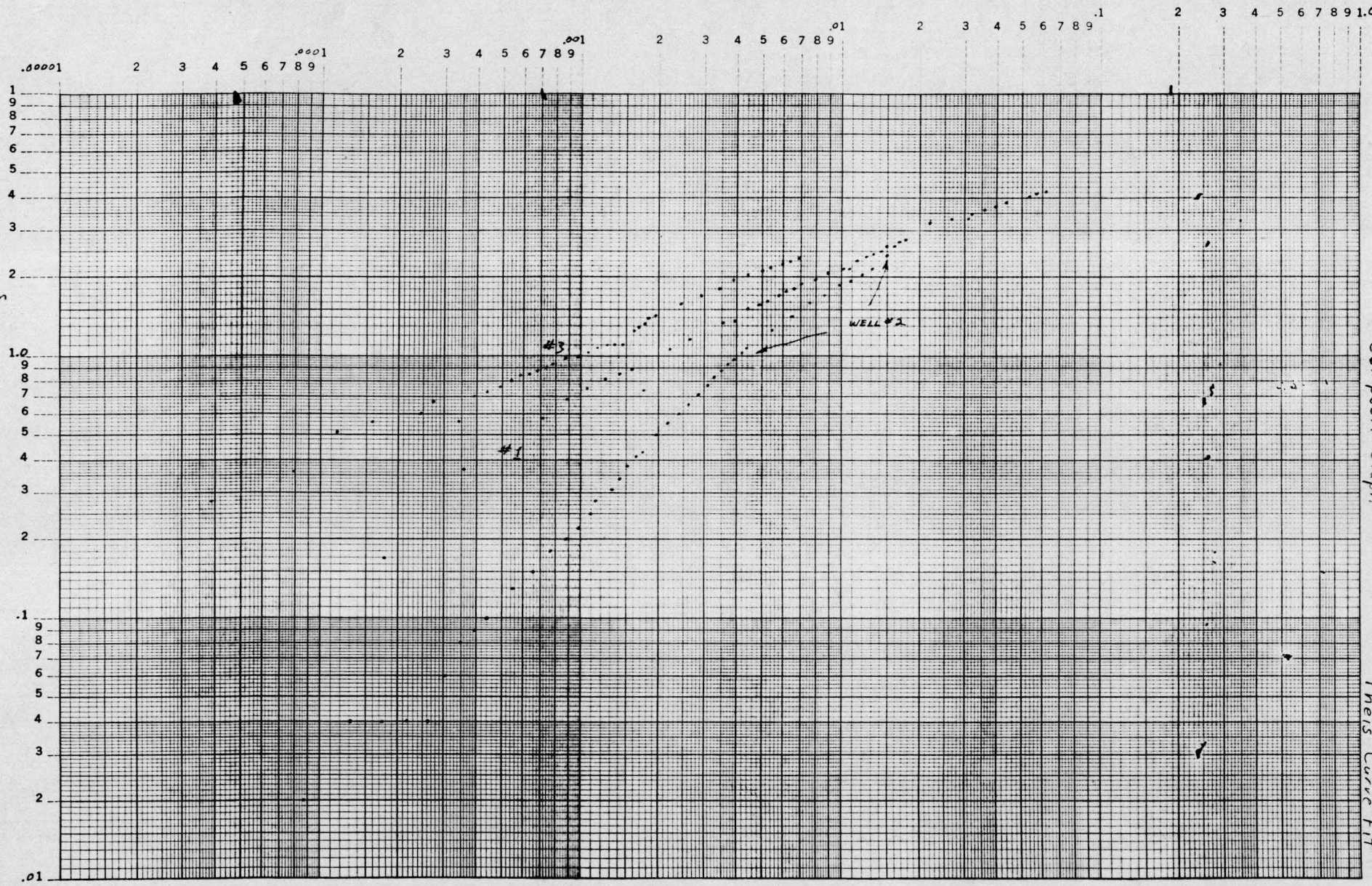


R. O. Bookstore #3

LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7522

composit Plot



s vs t/r²
R. D. Beckstorc

Appendix B-4

Theis Computer Regression Fit Method

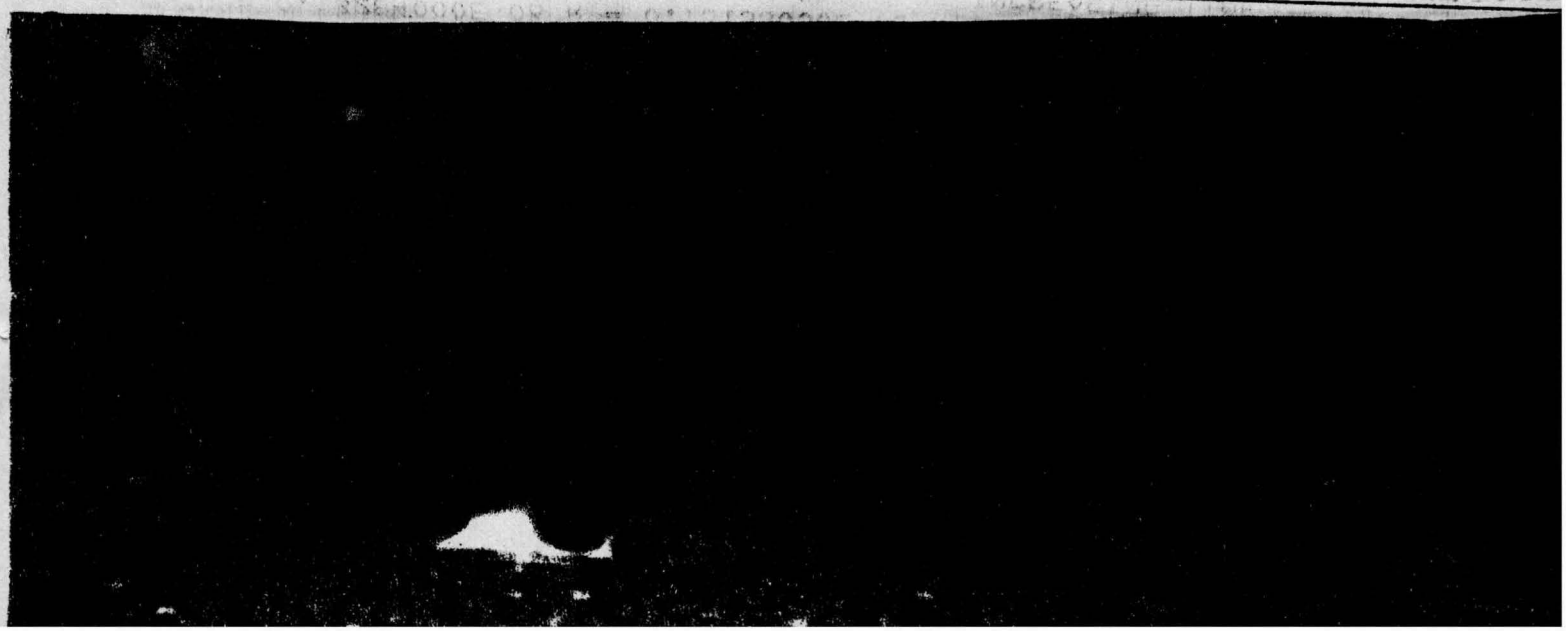
BEST FIT KB AND SC THIS ITERATION ARE 0.93820234E 04 0.31419925E-0

THE BEST FIT DRAWDOWN-TIME PAIRS ARE

KB = 70000 SC = .03

0.74729407E-07	0.13900000E-02
0.10698604E-04	0.20800000E-02
0.14274871E-03	0.27800000E-02
0.68759345E-03	0.34700000E-02
0.20451052E-02	0.41700000E-02
0.44853679E-02	0.48600000E-02
0.82633434E-02	0.55600000E-02
0.13332500E-01	0.62500000E-02
0.19712306E-01	0.69400000E-02
0.41029503E-01	0.86800000E-02
0.68015895E-01	0.10400000E-01
0.10067321E 00	0.12200000E-01
0.13425153E 00	0.13900000E-01
0.16947255E 00	0.15600000E-01
0.20776547E 00	0.17400000E-01
0.24434825E 00	0.19100000E-01
0.28095521E 00	0.20800000E-01
0.31947169E 00	0.22600000E-01
0.35543830E 00	0.24300000E-01
0.39088681E 00	0.26000000E-01
0.42776951E 00	0.27800000E-01
0.49737436E 00	0.31300000E-01
0.56219173E 00	0.34700000E-01
0.62602973E 00	0.38200000E-01
0.68703253E 00	0.41700000E-01
0.74371020E 00	0.45100000E-01
0.79955192E 00	0.48600000E-01
0.85301603E 00	0.52100000E-01
0.90426172E 00	0.55600000E-01
0.95206228E 00	0.59000000E-01
0.99936756E 00	0.62500000E-01
0.10448737E 01	0.66000000E-01
0.10874713E 01	0.69400000E-01
0.12841448E 01	0.86800000E-01
0.14504786E 01	0.10400000E 00
0.16020870E 01	0.12200000E 00
0.17288813E 01	0.13900000E 00
0.18429625E 01	0.15600000E 00
0.19524401E 01	0.17400000E 00
0.20469534E 01	0.19100000E 00
0.21341856E 01	0.20800000E 00
0.22950402E 01	0.24300000E 00

THE STANDARD DEVIATION FOR DRAWDOWN IS 0.45048270E-01



BEST FIT KB AND SC THIS ITERATION ARE [illegible]

BEST FIT KB AND SC THIS ITERATION ARE 0.10615698E 05 0.17678688E-01

THE BEST FIT DRAWDOWN-TIME PAIRS ARE

0.79583599E-02	0.69400000E-03
0.75155748E-01	0.13900000E-02
0.28472369E 00	0.27800000E-02
0.38819791E 00	0.34700000E-02
0.48675675E 00	0.41700000E-02
0.57715388E 00	0.48600000E-02
0.66235809E 00	0.55600000E-02
0.74050653E 00	0.62500000E-02
0.81345673E 00	0.69400000E-02
0.97791200E 00	0.86800000E-02
0.11184161E 01	0.10400000E-01
0.13558148E 01	0.13900000E-01
0.14537401E 01	0.15600000E-01
0.15480054E 01	0.17400000E-01
0.16295904E 01	0.19100000E-01
0.17050418E 01	0.20800000E-01
0.17791895E 01	0.22600000E-01
0.18445118E 01	0.24300000E-01
0.19058306E 01	0.26000000E-01
0.19669030E 01	0.27800000E-01
0.20759304E 01	0.31300000E-01
0.21715411E 01	0.34700000E-01
0.23114327E 01	0.40300000E-01
0.23435423E 01	0.41700000E-01
0.24174717E 01	0.45100000E-01
0.24882505E 01	0.48600000E-01
0.25543362E 01	0.52100000E-01
0.26163117E 01	0.55600000E-01
0.26730376E 01	0.59000000E-01
0.27282435E 01	0.62500000E-01
0.27805510E 01	0.66000000E-01
0.28288630E 01 [illegible]r2J[illegible]-01	
0.30449780E 01	0.86800000E-01
0.32205940E 01	0.10400000E 00
0.33762644E 01	0.12200000E 00
0.33999985E 01	0.12500000E 00
0.35247520E 01	0.14200000E 00
0.36169169E 01	0.15600000E 00
0.37127581E 01	0.17200000E 00
0.38310813E 01	0.19400000E 00
0.38996603E 01	0.20800000E 00
0.39900994E 01	0.22800000E 00
0.40529163E 01	0.24300000E 00

THE STANDARD DEVIATION FOR DRAWDOWN IS 0.140585O9E 00

*

T3 = 79400 gpd/ft

[illegible]

BEST FIT KB AND SC THIS ITERATION ARE 0.17980324E 05 0.46257057E-02

KB = 134490 gpd/ft SC = .005

THE BEST FIT DRAWDOWN-TIME PAIRS ARE

0.17377949E-01	0.13900000E-02
0.95290967E-01	0.27800000E-02
0.18582732E 00	0.41700000E-02
0.34770808E 00	0.69400000E-02
0.43368611E 00	0.86800000E-02
0.50879648E 00	0.10400000E-01
0.57882426E 00	0.12200000E-01
0.63836343E 00	0.13900000E-01
0.69259057E 00	0.15600000E-01
0.74514749E 00	0.17400000E-01
0.79088618E 00	0.19100000E-01
0.83337369E 00	0.20800000E-01
0.87528686E 00	0.22600000E-01
0.91233175E 00	0.24300000E-01
0.94720112E 00	0.26000000E-01
0.98201528E 00	0.27800000E-01
0.10443590E 01	0.31300000E-01
0.10992148E 01	0.34700000E-01
0.11508206E 01	0.38200000E-01
0.11982751E 01	0.41700000E-01
0.12409842E 01	0.45100000E-01
0.12819388E 01	0.48600000E-01
0.13202315E 01	0.52100000E-01
0.13561864E 01	0.55600000E-01
0.13891306E 01	0.59000000E-01
0.14212221E 01	0.62500000E-01
0.14516545E 01	0.66000000E-01
0.14797833E 01	0.69400000E-01
0.16058347E 01	0.86800000E-01
0.17084939E 01	0.10400000E 00
0.17996355E 01	0.12200000E 00
0.18744140E 01	0.13900000E 00
0.19407477E 01	0.15600000E 00
0.20036766E 01	0.17400000E 00
0.20574996E 01	0.19100000E 00
0.21068065E 01	0.20800000E 00
0.21599714E 01	0.22800000E 00
0.21969106E 01	0.24300000E 00

THE STANDARD DEVIATION FOR DRAWDOWN IS 0.12764176E 00

*

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