United States
Department of the Interior
Geological Survey

Water supply, Army Air Force Flexible Gunnery School, Kingman, Arizona

By

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Subject: Water supply, Army Air Force Flexible Gunnery School, Kingman, Arizona

Memorandum to: Head, Sanitary Section
(Through Chief, Military Design Subdivision)

1. This memorandum is submitted in order to make of record the details of the field investigation of subject water supply made by Mr. S. F. Turner of the U. S. Geological Survey and the writer during the period from 11 August to 21 August 1943.

2. Hackberry Well. - In accordance with the recommendations Messrs. Turner and Poland of the U. S. Geological Survey, submitted in their report of 19 April 1943, and in which the writer concurs, a 16-inch well is in process of drilling at the recommended location, about 17 miles northeast of the camp. This well, when visited on 12 August 1943, was cased to 330 feet and uncased to a total depth of about 700 feet. The water level stood at 500 feet. A bailer test took out 300 gallons in 9-1/2 minutes and lowered the water level 15 feet. A second test took out 650 gallons in 32 minutes and lowered the water level 15 feet. On 13 August 1943, the depth of the well was extended to 720 feet, and it started caving below the water surface.

3. Unwashed samples of the materials encountered at depths of 550 feet, 588 to 590 feet, and 598 to 600 feet, were tested for permeability and specific yield with the following results:

Tests on samples from Hackberry Wash test well
(Samples not washed)

Depth (ft.)	Meinzer's coeff. of permeability by variable head appar.	Yield by draining in % of volume	Moisture retained in % of volume	Porosity % by volume	Specific gravity	Apparent or gross specific gravity
550	55.3	7.0	31.5	38.5	2.70	1.67
588-590	430	17.0	17.7	34.7	2.67	1.75
598-600	260	12.0	19.2	31.2	2.60	1.79

4. Although the bailer tests were not encouraging, the results of the permeability tests on materials from 588 to 600 feet, together with the fact that the well was caving, indicated the possibility that it might be further developed. The specific yields of 17 per cent and 12 per cent are high and indicate there would be but a moderate lowering of the water table, as the result of continuous pumping.

5. In light of the extreme importance of this possible source of water supply, further exploration was deemed justified. It is therefore proposed to extend the well to a 1,000-foot depth, case and perforate. A pump should then be installed and a thorough development program initiated. Contingent on the results obtained, it may be desirable to sink another well about a mile or so northeasterly from the present site in further exploration of this source of supply.

6. Johnson Spring area. - In an effort to determine the extent of the present source of supply in the Johnson Spring area and the rate of recession of the water table in the three wells now operated, recovery tests were made upon each of the wells. The well was shut down after a period of 7 hours or more of continuous pumping and the rate of recovery

of the water table measured during the succeeding 24 hours. The results of these observations are shown on diagrams Nos. 1 and 2. One purpose of this test was to determine whether the water-bearing materials were approximately homogeneous or were cavernous, such as are frequently encountered in limestone formations. The resulting recovery curves are, without exception, smooth and do not indicate a cavernous condition. It was therefore thought that the recovery formula developed by Mr. C. V. Theis of the U. S. Geological Survey might be applicable to these materials. A discussion of this formula is given on pages 95 and 96 of U. S. Geological Survey Water Supply Paper No. 887.

7. The pumping records obtained by the Post Engineer were searched in an effort to assemble the required data. These, together with the resulting computations, were the coefficient of transmissibility, and are shown on the attached tables Nos. 1, 2, and 3. Curves for the resulting values of the coefficient of transmissibility are shown on diagrams Nos. 3 and 4. By exterpolating these curves, coefficients of transmissibility may be estimated and introduced into the Theis formula to solve for anticipated water levels resulting from continuous pumping operations in the future. Well No. 4 had been operated for a period of only 26 days, and sufficient data are not available on which to make similar computations for this well.

8. Too much confidence should not be placed in the results of these computations in as much as the formula has not been thoroughly tested under field conditions, and analysis of the data available in this instance leaves doubt as to its applicability.

9. Another approach to the problem was made by plotting the static water levels against the total production from each of the wells. These results are shown on diagrams Nos. 5 and 6. By exterpolating the apparent rate of recession to the depth at which the pump bowls are to be set, an estimate can be made of the apparent volume of water remaining in storage above the pump bowls. With a pump setting of 190 feet in well No. 1, there is an apparent storage of 39.7 million gallons. If the well is pumped at the rate of 150 gallons per minute for 16 hours a day, this supply could be maintained for a period of 275 days or say 9 months, when the water levels will have reached a depth of 190 feet. Checking this by the Theis formula for the coefficients of transmissibility indicates water levels of 208 to 241 feet at this time.

10. With the proposed pump setting of 170 feet in well No. 2, there is an apparent storage of 30.5 million gallons above the pump bowls. (See diagram No. 6.) If this well is pumped at 150 gallons per minute for 16 hours a day, the supply will last approximately 212 days or 7 months, with a resulting water level of 170 feet at the end of that period. A check by the Theis formula indicates a depth of 154 feet.

11. During the 26 days that well No. 4 was pumped, it produced 4.9 million gallons, and the water level fell 5.4 feet. The proposed setting of the pump bowls is 100 feet, and if it is assumed that the present rate of recession of the water table, as related to the volume of water pumped, will continue, the total amount of water remaining in storage above the pump bowls is approximately 42 million gallons. If pumped at the rate of 200 gallons per minute for 16 hours a day, this will last 145 days or about 5 months.

12. The conclusions submitted by teletype dated 19 August 1943, KGN 87, reference 45, from Mr. Saunders, Area Engineer, Kingman, Arizona, to the District Engineer, attention of Mr. C. F. Hostrup, were based upon rapid field analysis of these data. More detailed studies recently made indicate that these conclusions are probably too optimistic. It is the writer's opinion at this time that a water supply from this area at the rate of 500,000 gallons a day cannot be depended upon with assurance beyond a period of about 6 months.

13. The day following that upon which the above-referenced teletype was sent, the writer examined the out-wash slopes of the Hualpai Mountains. These do not look promising from a water supply standpoint, and their exploration by test wells is not now recommended.

14. On 19 August 1943 three wells in the lower part of Hackberry Wash north of the railroad station were examined. That at the Valentine Indian School is a dug well, 42 feet deep and 25 feet in diameter. It is equipped with two turbine pumps with a capacity of 250 gallons per minute each. The pump operator stated that they had not been able to pump the well dry with these two pumps in operation for periods of 15 days or more, although the water level dropped about 12 feet.

15. About a mile upstream from the Valentine Indian School, at the Valentine Post Office, Mr. E. F. Holt has two wells - one a 10-inch casing, 60 feet deep from the bottom of a 12-foot pit about 20 feet deep. It is equipped with a 4-inch horizontal centrifugal pump said to have a capacity of 700 gallons per minute. The second well is 75 feet of 16-inch casing at the bottom of a 15-foot pit. It is equipped with a 6-inch horizontal centrifugal pump said to have a capacity of 1,200

gallons per minute. Mr. Holt said that both of these wells would sustain a pump discharge for periods of 5 days. The appearance of the irrigation ditches indicated that flows up to about 2 second-feet had probably been handled through them. The width of the canyon at this point is not over a mile, and the alluvium is apparently free and yields its water readily.

16. The fact that no heavy wash material was encountered in the log of the Hackberry Well and the apparent volume of underflow in Hackberry Wash near the Valentine Post Office suggests the possibility that the upper Hackberry Wash may have drained into the Big Sandy in previous geologic times and that the present underflow may possibly pass under the low divide at the head of the Big Sandy. With this in mind, it is suggested that if further exploration by wells is contemplated, that an exploratory hole might be drilled along the south bank of Hackberry Wash where it turns westerly toward Hackberry railroad station.

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Major, Corps of Engineers,
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ERB:MYK

9 Inclosures

Inclosure	1 -	Table No.	1 -	Well No.	1,	
"	2 -	" "	2 -	" "	1A,	
"	3 -	" "	3 -	" "	2,	
"	4 -	Diagram No.	1,			
"	5 -	" "	2,			
"	6 -	" "	3,			
"	7 -	" "	4,			
"	8 -	" "	5,			
"	9 -	" "	6.			

(See next page)

cc ME
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408 N. Fourth Avenue, Tucson, Arizona.
Communications Subdivision.

TABLE NO. 1
WELL NO. 1

Computations for Coefficient of Transmissibility "T"
Initial Pumping January 1, 1943 – Initial Static W.L. = 12'

Pumping Stopped		t	t'	log t/t'	Static W.L. at t' ft.	Residual draw down "S" in ft.	Volume Pumped 1000-Gals.	Average rate = Q gpm	264 x Col. (9) x Col. (5)	T = Col. (10) ÷ (7)
Date	Time	hrs.	hrs.							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Feb. 26	1:00 P.M.	1357	43	1.513	25	13	7,275	89.4	35,700	2,745
Mar. 5	4:00 P.M.	1528	40	1.583	35	23	8,017	87.5	36,600	1,590
Apr. 12	3:00 P.M.	2439	20	2.090	41	29	10,229	70.0	38,600	1,330
Apr. 26	5:00 P.M.	2777	39	1.859	39	27	12,444	75.0	36,800	1,362
Jun. 23	10:00 P.M.	4174	8	2.719	75	63	22,646	90.6	64,600	1,025
Jul. 31	8:00 P.M.	5084	5	3.033	80	68	28,114	92.3	73,800	1,085
Aug. 15	2:35 P.M.	5438.5	24	2.357	89.7	77.7	29,257	90	56,000	720
Aug. 15	2:35 P.M.	5438.5	2	3.435	95	83	29,257	90	81,500	982
Sept. 2	9:00 P.M.	6058	181	1.525	77.9	67.9	31,007	88	35,422	522
Oct. 29-30	Mid.	7248	8	2.958	92	82	34,693	80	62,473	762
Dec. 2	12 P.M.	8040	8	2.968	96.5	86.5	37,405	78	61,137	707
Dec. 16	12 P.M.	8376	8	2.999	93.4	83.4	38,298	76	60,172	721
Dec. 30	12 P.M.	8712	8	3.011	94.1	84.1	39,309	75	59,617	709
Jan. 13	12 P.M.	9048	8	3.038	94.05	84.05	39,982	74	59,350	706
Jan. 28	12 P.M.	9408	8	3.044	93.4	83.4	40,915	72	57,860	694
Feb. 10	12 P.M.	9720	8	3.055	90.15	80.15	41,588	71	57,263	714
Feb. 24	12 P.M.	10056	8	3.078	94.68	84.68	42,577	70	56,881	672
Mar. 9	12 P.M.	10392	8	3.088	84.65	74.65	43,594	69	56,251	754
Apr. 27	12 P.M.	11544	20	2.763	96.88	86.88	46,614	67	48,872	563

TABLE NO. 2
WELL NO. 1A

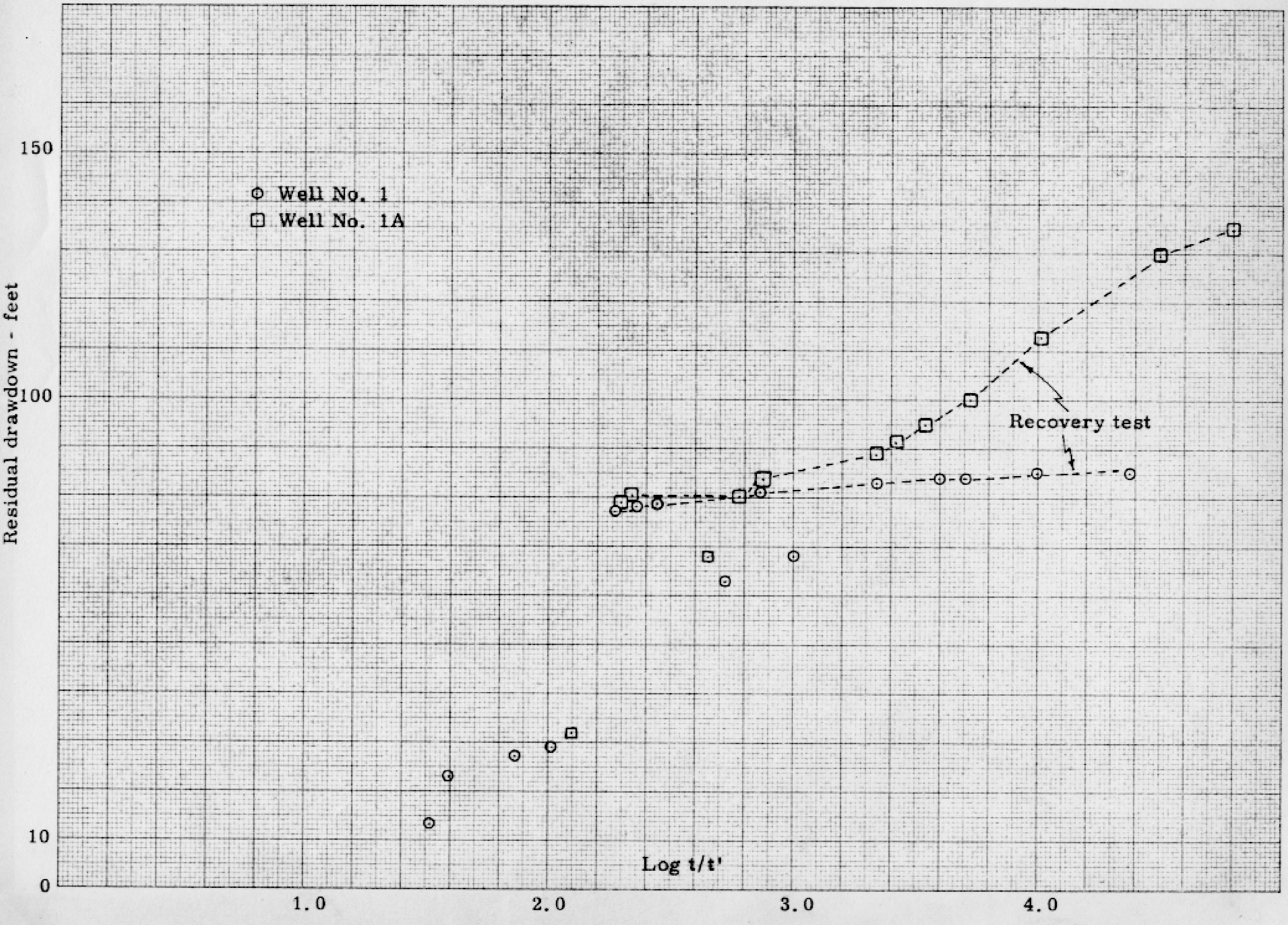
Computations for Coefficient of Transmissibility "T"
Initial Pumping January 1, 1943 - Initial Static W.L. = 10'

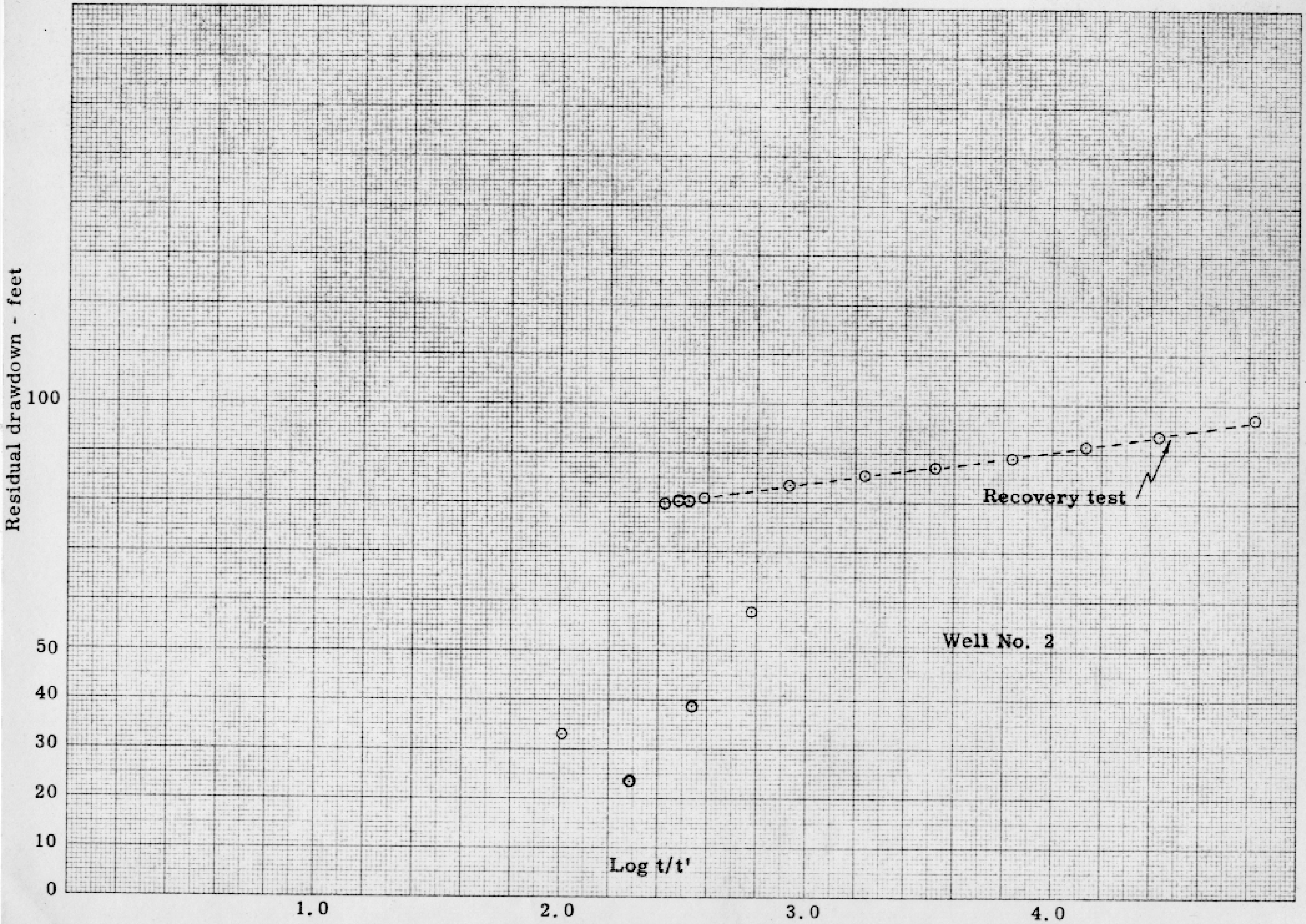
Pumping Stopped		t	t'	log t/t'	Static W.L.	Residual	Volume	Average	264 x Col. (9)	T =
Date	Time				at t'	draw down	Pumped	Rate = Q	x Col. (5)	Col. (10)
		hrs.	hrs.		ft.	"S" in ft.	1000-Gals.	gpm		÷ (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Apr. 12	3:00 P.M.	2459	20	2.090	42.3	32.3	10,229	70	38,600	1,195
May 29	11:00 P.M.	3583	8	2.651	78	68	18,991	89	62,000	913
Aug. 15	2:35 P.M.	5462.5	24	2.357	91.4	81.4	29,257	90	56,000	688
Aug. 15	2:35 P.M.	5440.5	2	3.435	103.1	93.1	29,257	90	81,500	875
Sept. 2	9:00 P.M.	6058	181	1.525	77.9	67.9	45,846	130	52,328	771
Sept. 13	12:00 Mid.	7584	328	1.382	75	63.4	45,846	101	36,860	581
Dec. 16	12 P.M.	8376	8	2.999	94.6	84.6	38,298	76	60,172	711
Dec. 30	12 P.M.	8712	8	3.011	94.3	84.3	39,309	75	59,617	707
Jan. 13	12 P.M.	9048	8	3.038	95.25	85.25	39,982	74	59,350	696
Jan. 28	12 P.M.	9432	8	3.046	94.6	84.6	40,915	72	57,898	684
Feb. 10	12 P.M.	9744	8	3.056	91.35	81.35	41,588	71	57,282	704
Feb. 24	12 P.M.	10080	8	3.079	95.88	85.88	42,577	70	56,900	662
Mar. 9	12 P.M.	10416	8	3.089	85.85	75.85	43,594	69	56,269	742
Apr. 27	12 P.M.	11592	20	2.765	98.08	88.08	46,614	67	48,907	555

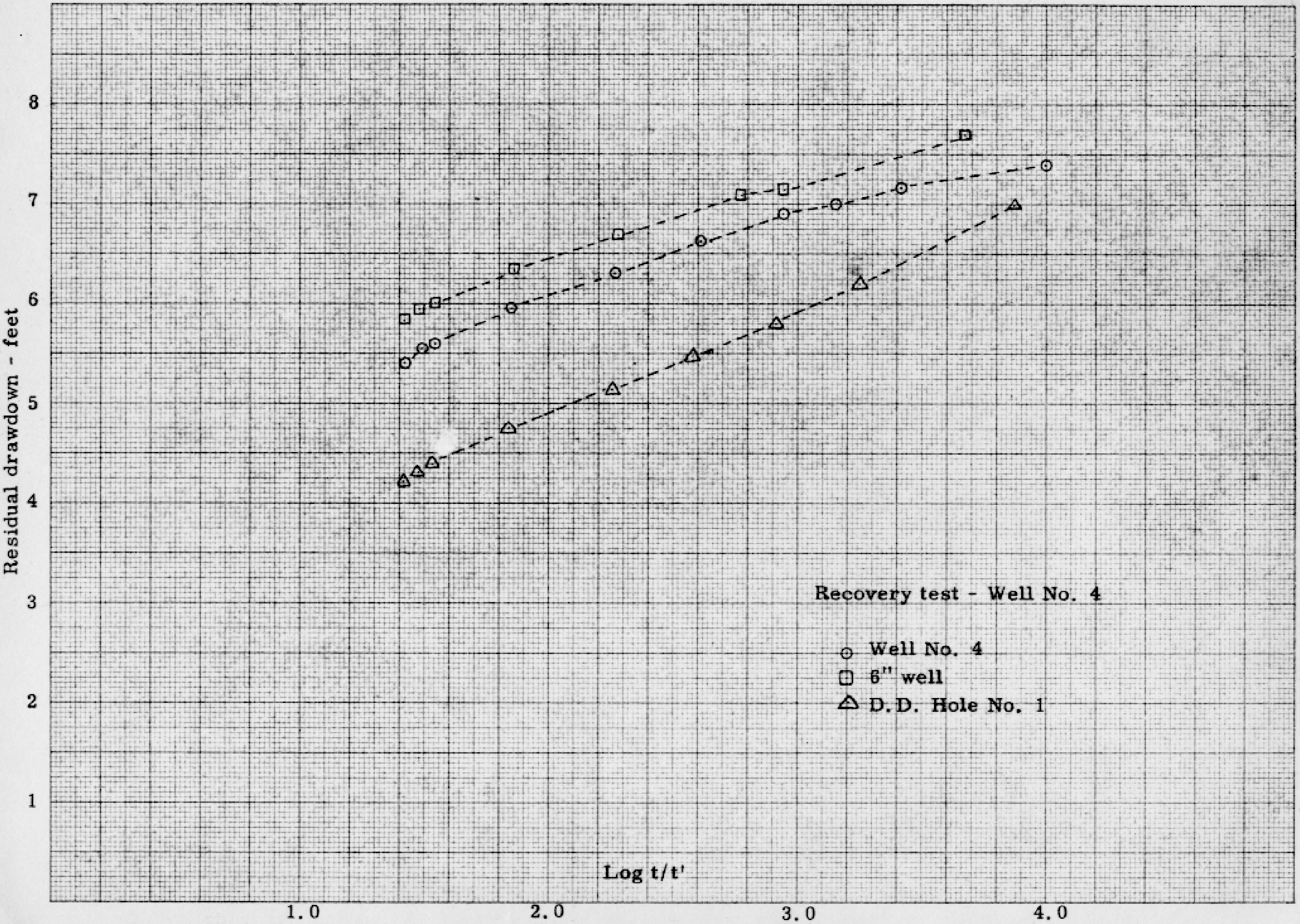
TABLE NO. 3
WELL NO. 2

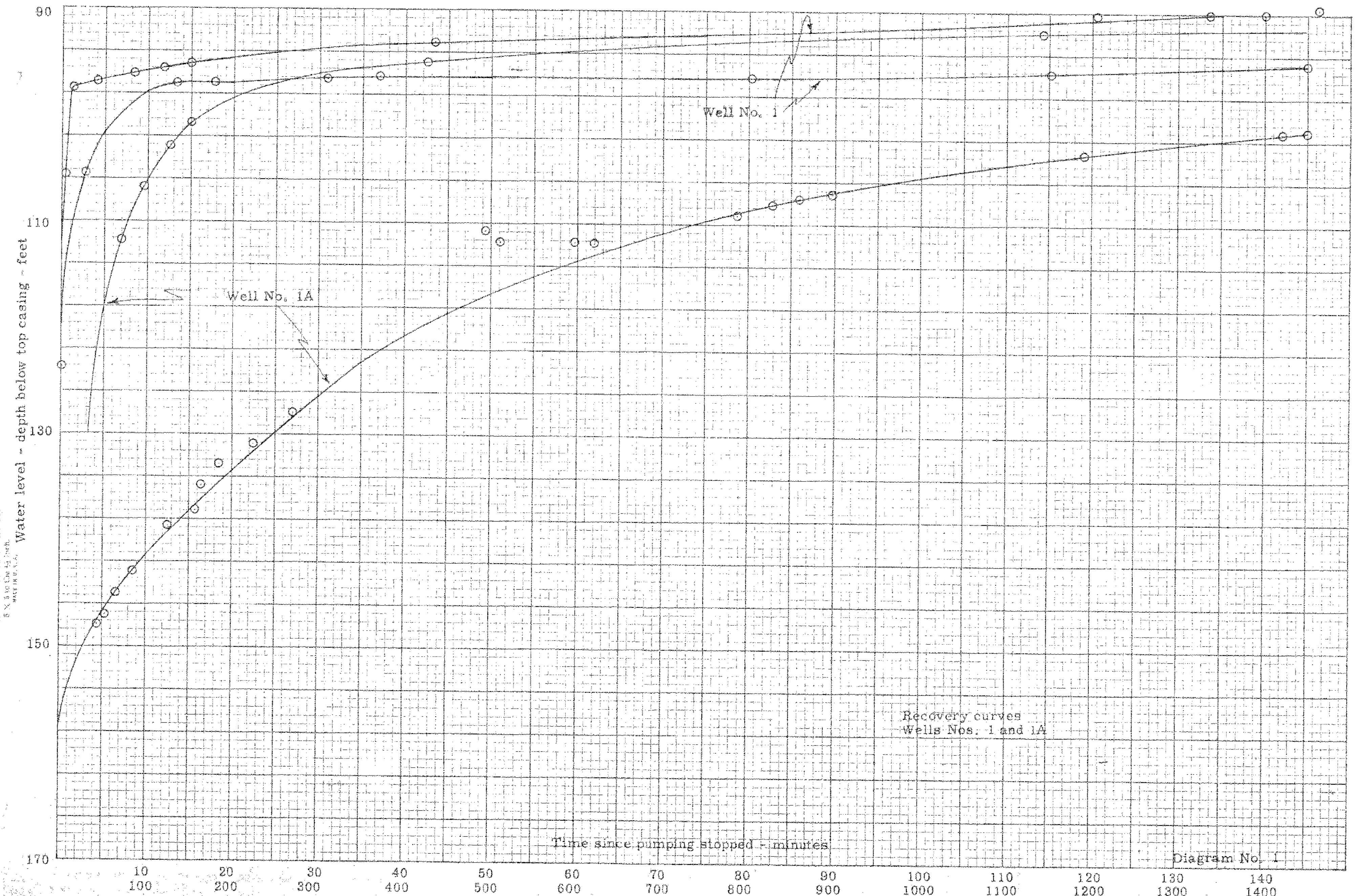
Computations for Coefficient of Transmissibility "T"
Initial Pumping - 60 days prior to Jan. 1, 1943. Initial Static W.L. = 11.6'

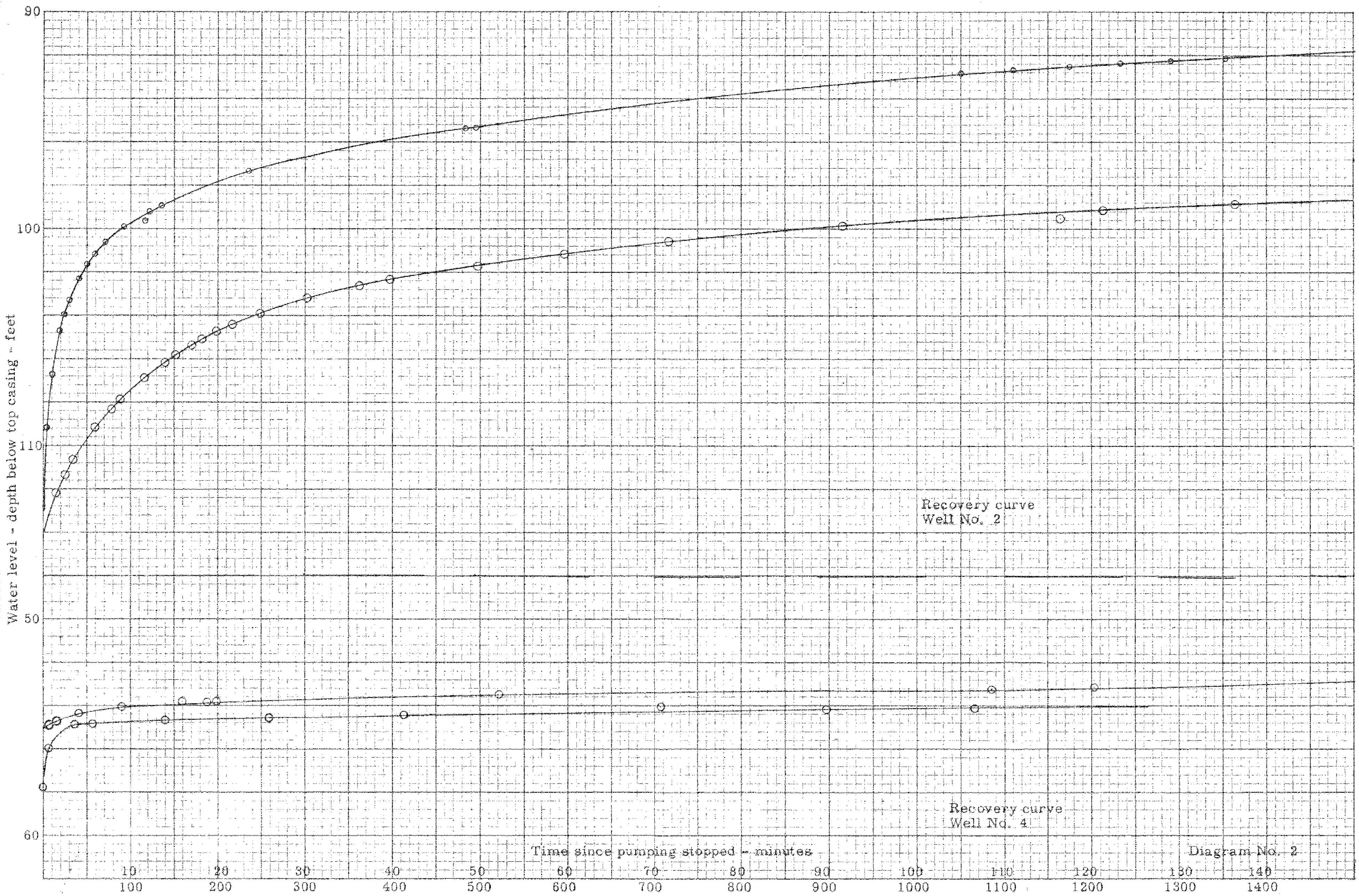
Pumping Stopped		t	t'	log t/t'	Static W.L.	Residual	Volume	Average	264 x Col. (9)	T =
Date	Time	hrs.*	hrs.		at t' ft.	draw down "S" in ft.	Pumped 1000-Gals.	Rate = Q gpm	x Col. (5)	Col. (10) ÷ (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Mar. 11	4:00 P.M.	3128	16	2.291	35	23.4	8,844	47.3	28,600	1,223
Mar. 31	4:00 P.M.	3611	35	2.014	45	33.4	12,940	60.4	32,120	963
Apr. 11	9:00 P.M.	3872	11	2.547	50	38.4	15,224	65.7	44,100	1,148
May 24	12:00 MN	4904	8	2.787	70	58.4	23,371	79.5	58,400	1,000
Aug. 16	2:23 P.M.	6926.5	24	2.460	91.8	80.2	41,496	100	65,000	810
Sept. 13	12:00 Mid.	7912	328	1.382	75	63.4	45,875	101	36,860	581
Oct. 29	12:00 Mid.	8688	8	3.036	98	86.4	50,666	97.4	78,068	903
Dec. 16	12:00 P.M.	9840	8	3.091	103	91.4	57,011	96	78,338	857
Feb. 10	12:00 P.M.	10752	8	3.129	105	93.4	62,507	97	80,127	858
Mar. 9	12:00 P.M.	11424	8	3.155	100	88.4	65,235	95	79,127	895
Mar. 29	12:00 P.M.	11904	8	3.173	105	93.4	66,786	93	77,830	834
Apr. 26	12:00 P.M.	12576	8	3.197	110	98.4	69,520	92	77,649	789

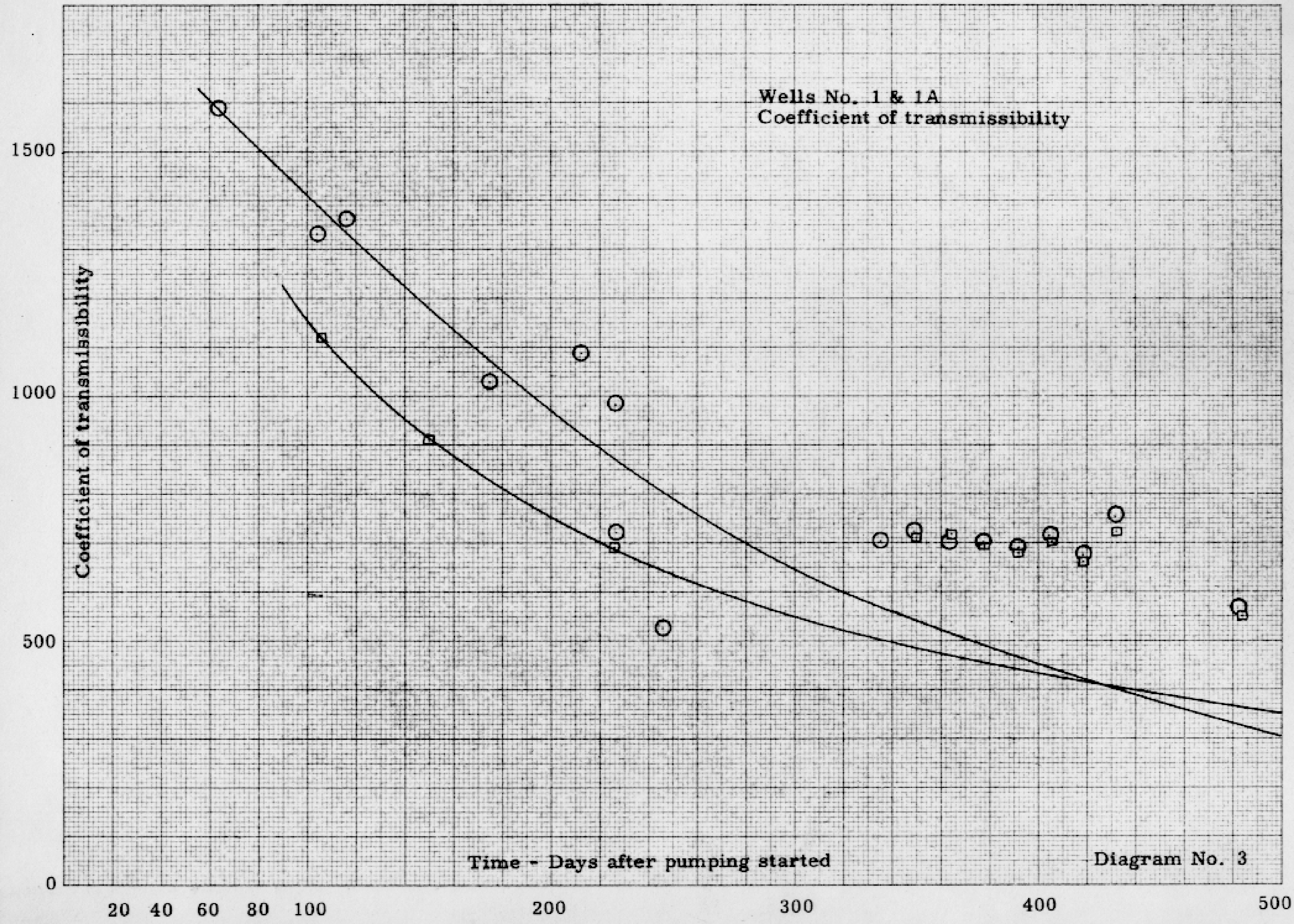

Well No. 1
Well No. 1A
Recovery test
Residual drawdown - feet
150
100
10
0
Log t/t'
1.0
2.0
3.0
4.0

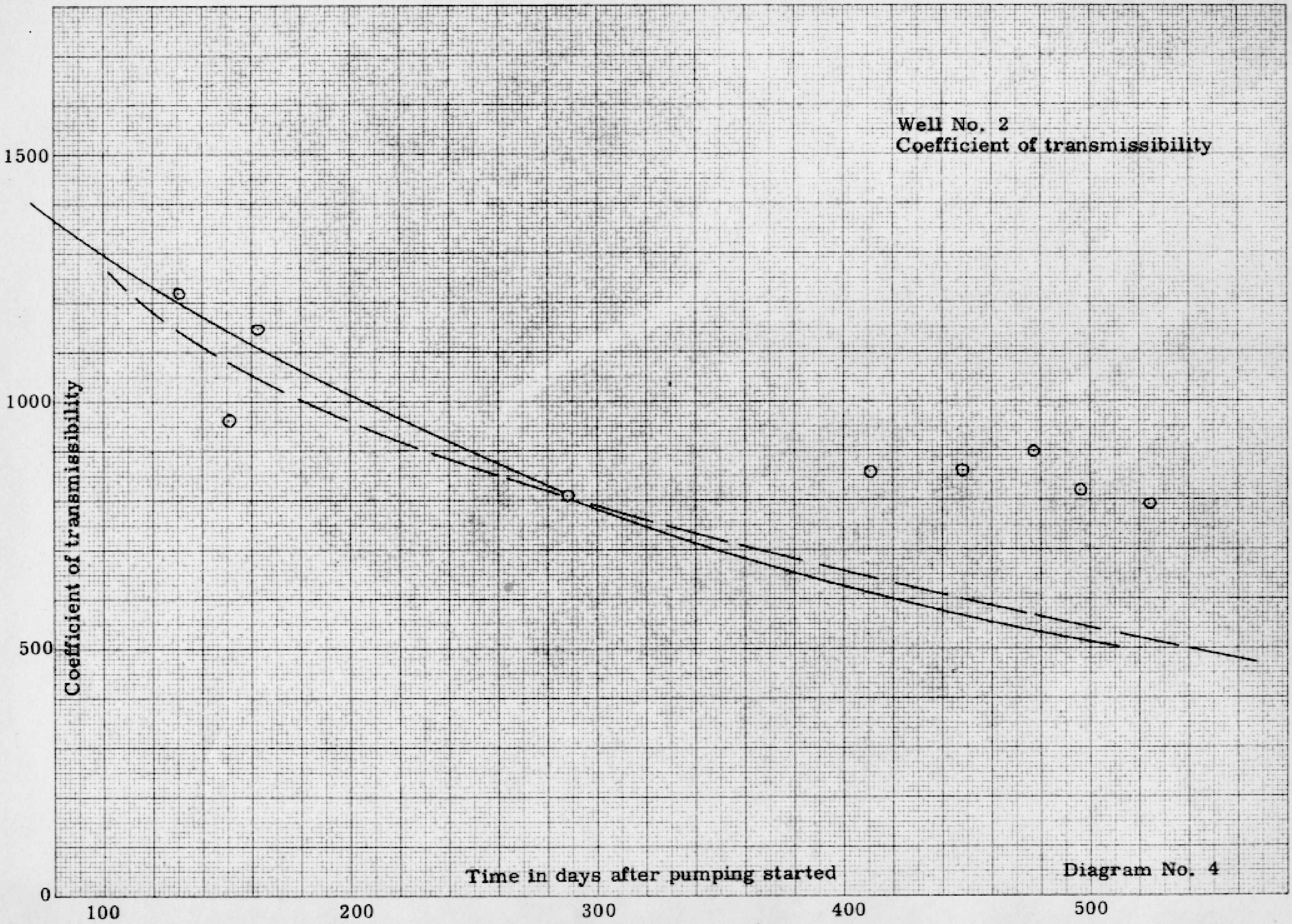

Residual drawdown - feet
100
50
40
30
20
10
0
1.0
2.0
3.0
4.0
Log t/t'
Recovery test
Well No. 2

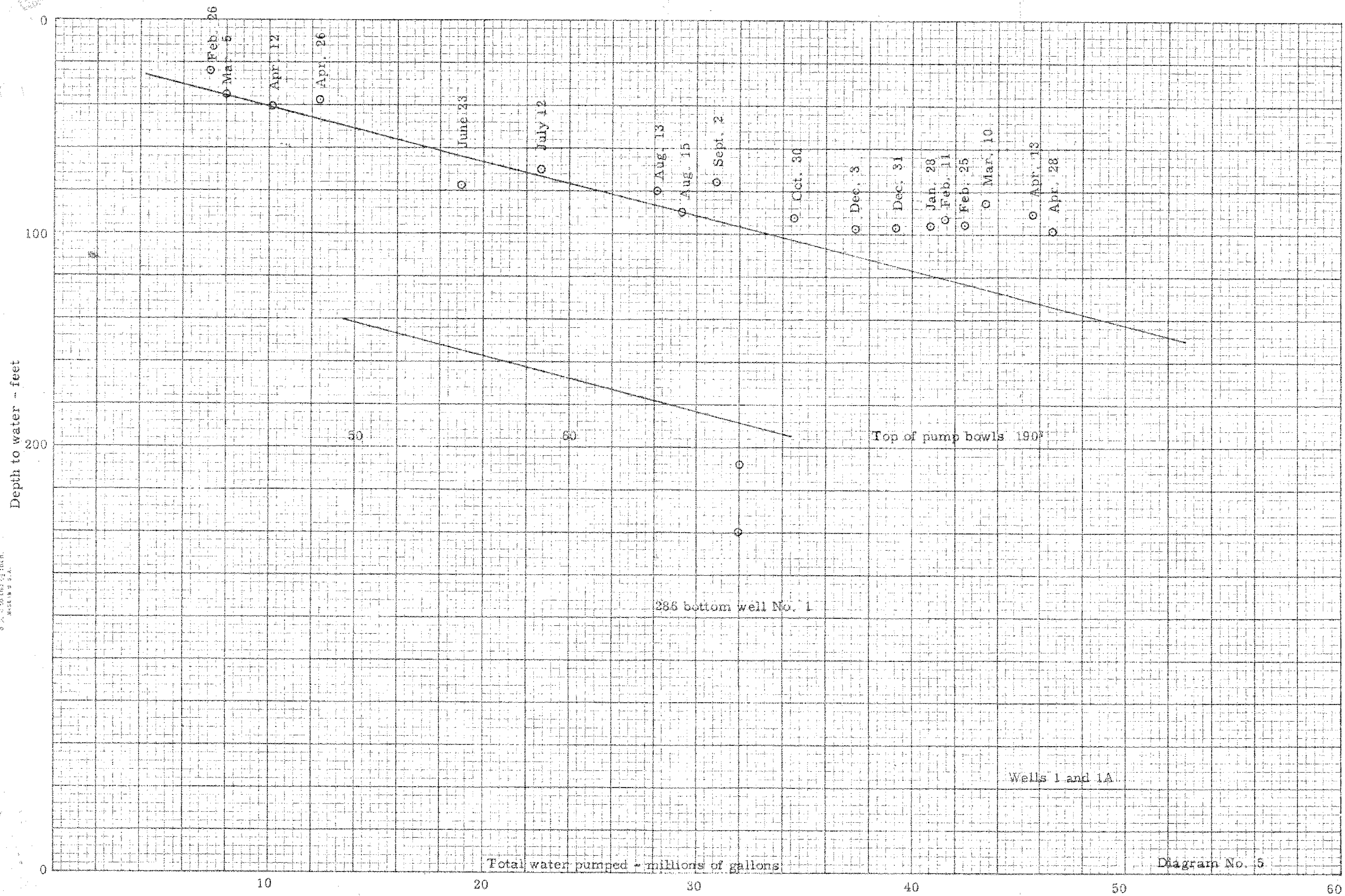

Recovery test - Well No. 4
Well No. 4
6" well
D.D. Hole No. 1
Residual drawdown - feet
Log t/t'
1
2
3
4
5
6
7
8
1.0
2.0
3.0
4.0


Well No. 1
Well No. 1A
Water level - depth below top casing - feet
90
110
130
150
170
Time since pumping stopped - minutes
10 100
20 200
30 300
40 400
50 500
60 600
70 700
80 800
90 900
100 1000
110 1100
120 1200
130 1300
140 1400
Recovery curves
Wells Nos. 1 and 1A
Diagram No. 1


90
100
110
50
60
Water level - depth below top casing - feet
Recovery curve
Well No. 2
Recovery curve
Well No. 4
Time since pumping stopped - minutes
10 20 30 40 50 60 70 80 90 100 110 120 130 140
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400
Diagram No. 2


Wells No. 1 & 1A
Coefficient of transmissibility
Coefficient of transmissibility
1500
1000
500
0
20
40
60
80
100
200
300
400
500
Time - Days after pumping started
Diagram No. 3


Well No. 2
Coefficient of transmissibility
1500
1000
500
0
Coefficient of transmissibility
100
200
300
400
500
Time in days after pumping started
Diagram No. 4



Feb. 26
Mar. 6
Apr. 12
Apr. 26
June 23
July 12
Aug. 13
Aug. 15
Sept. 2
Oct. 30
Dec. 3
Dec. 31
Jan. 28
Feb. 11
Feb. 25
Mar. 10
Apr. 13
Apr. 28
50
60
Top of pump bowls 190'
286 bottom well No. 1
Wells 1 and 1A
Depth to water - feet
0
100
200
0
Total water pumped - millions of gallons
10
20
30
40
50
60

Diagram No. 5