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Stettler Groundwater Exploration Program, 1962

38 - 20 - W4

Report

by

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ALBERTA RESEARCH COUNCIL

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Introduction and Summary

In the summer of 1962, the Research Council of Alberta was approached by the town of Stettler about additional groundwater exploration in the Stettler area, with a view on the future growth of the town and in anticipation of the steadily growing demand for water.

After a preliminary investigation of the available data, an area 3 miles west of Stettler was outlined as being prospective on the basis of water-well logs and seismic shothole logs indicating a deep bedrock surface and the presence of a considerable thickness of sand. The presence of a buried bedrock channel in this general area has since long been suspected, but it never has been accurately located.

From August 29, 1962, to September 4, 1962, ten testholes were put down in Sections 32 and 33 of Tp. 38, R. 20, W. 4th M. and Section 3 and 4, Tp. 39, R. 20, W. 4th M. (Figure 1). Only in testhole #62-4, Lsd 15, Sec. 33, Tp. 38, R. 20, W. 4 M., the channel was located (depth to bedrock 210 feet) and a pump test was subsequently conducted at this location. Data obtained from this test indicate that the channel is approximately 1300 feet wide at this location. The transmissibility of the aquifer is approximately 8000 Imp. gallons/day foot with a storage coefficient of 1.7×10^{-4}. The aquifer is capable of producing ~~195~~ 175 gallons per minute continuously for a period of 20 years at one location, but the nature of the aquifer material and its limited thickness would not permit a single well to produce at this rate without considerable well loss and consequently a shorter well-life.

Test Drilling Program

The purpose of the 1962 test program was to locate a buried channel approximately four miles west of Stettler, the evidence of its existence consisting of the log from a well drilled in the SE quarter of Section 4, Township 39, Range 20, West of the 4th Meridian, indicating the occurrence of sand and clay to 190 feet below surface, at which depth the hole had been abandoned.

The first test hole drilled was located approximately 1/2 mile east and 1/2 mile south of this location, but it encountered the Edmonton shale and sandstone at a depth of 94 feet. Fine sand and gravel was encountered from 55 - 70 feet.

Test holes # 2 and #3 encountered bedrock at respectively 57 feet and 80 feet; no coarse material was present at these locations.

Test hole #4 encountered the bedrock at a depth of 210 feet after penetrating a thick sand deposit from 60-110 feet below surface and sand underlain by 10 feet of gravel on top of the bedrock. After completion of the test drilling, a screened well and two observation wells were put in at this location and a pump test conducted.

Test hole #5 penetrated 30 feet of gravel and sand from 37-67 feet below surface. The bedrock surface is 80 feet below surface.

Test holes # 6, 7, 8, 9, and 10 did not encounter appreciable thicknesses of coarse sediments and depth to bedrock ranged from 32-80 feet.

Detailed logs of the test holes are contained in Appendix A of this report.

On the basis of this newly acquired information together with the information already at hand, a bedrock topography map of the area between Stettler and Erskine was prepared (Figure 2). The channel extends eastwards to a point approximately 1/6 of a mile south of the NE corner of Section 33, Township 39, Range 20, West 4th Meridian; from there it runs approximately WNW, then bends to the WSW to continue directly south of Erskine to join with the N trending Erskine channel.

Pump Test Procedure

For the determination of the aquifer constants a test well and two observation wells were constructed, the test well at the location of test hole #62-4, the observation wells at distances of 100 feet and 500 feet west respectively. Both the test well and the first observation well (at 100 feet) were drilled to and screened in the gravel deposit directly on top of the bedrock; the second observation well was drilled to a depth of 100 feet and screened over the bottom 5 feet of the sand and gravel deposit at this depth, its purpose being mainly to discover if any hydrologic connection existed between the two permeable zones.

Data on the completion and development of the wells are contained in Appendix B.

A 48-hour pump test was conducted at a constant rate of 70 gpm, whereafter the recovery was measured for a period of 6 hours, after which time the water levels in the test well and in observation well #1 had recovered to within 5.2 feet and 5.45 feet respectively, of their original nonpumping level.

A step-drawdown test was finally conducted, pumping the well at 46 gpm for the 1st hour, 61 gpm for the second hour and 82 gpm for the 3rd and last hour. Data obtained from this test were used to evaluate the efficiency of the well.

All pump test data are compiled in Appendix C.

Pump Test Analysis

A. Aquifer Constants

Aquifer constants were computed using both the leaky aquifer type curve and the straight line method (Theis modified nonequilibrium formula) on the following data:

drawdown observation well #1. Both type curve and straight line method.

drawdown pumped well ____________ not used ____________

recovery pumped well ____________ straight line method

recovery observation well #1 ________ straight line method

When the straight line method was used on the drawdown data of observation well #1, several straight line segments appeared due to the boundaries of the aquifer; theoretically, the slope of these segments should increase towards the end of the test in such a way that the drawdown per log cycle (Δ s) on each segment first doubles, then triples, etc., the Δ s of the first segment. Δ s values of respectively 1, 9 ft., 3.8 ft. and 5.7 ft. match the observed values quite closely, but when the values for the transmissibility (T) and the storage coefficient thus found are substituted in the t_{s1} formula, which indicates the time after which the time-drawdown data should fall on a straight line, it is found that the entire segment $\Delta s = 1.9$ lies before this limit of 17 minutes. Theoretically, therefore, the straight line method should not be used in this case.

With the type curve method an excellent match could be obtained between theoretical and observed drawdown; T and S valued thus calculated should be reliable. The recovery data on both the pumped well and observation well #1 yield values for T in close agreement with the T value obtained from the drawdown data of observation well #1 if the early recovery data $t/t' > 500$ are discarded, the straight line method not being applicable here.

The effect of hydrological boundaries on the drawdown in pumped well and observation well are the same as the effect of a so-called image-well pumping at the same rate as the pumped well and located on a straight line through the pumped well and perpendicular to the boundary at the same distance from the boundary as the pumped well but on the opposite side, hence, the name "image well". The distance of such an image well from an observation well can readily be calculated from a straight line plot of time-drawdown data or from a type curve plot. Two boundaries are showing on the plots; the closer of the two was calculated using both methods, which show excellent agreement, the farther was calculated from the straight line method.

Results of the calculations of T, S and the distances to the boundaries are summarized in Table 1.

B. Safe Yield of Aquifer

The following safe yields are calculated using the Theis nonequilibrium formula and the aquifer coefficients established previously. The well is assumed to be 100% efficient. The pumping rates are calculated for a 4" ~~and a 6~~" well with a 170 foot available drawdown over a 20-year period. A 75% safety factor is included. The safe yield gives an estimate of the potential of the aquifer.

Table 1

Well	Data used and method used	Transmiss-ibility in gpd/ft.	Storage coefficient	Distance between observation well #1 and image well = d_2 (ft.)	Distance between observation well #1 and 2nd image well = d_2 (ft.)	Width of channel (ft) = $\frac{d_1 + d_2}{2}$
Pumped well	drawdown		n o t	u s e d		
Pumped well	recovery straight line	7300	-	-	-	-
Obser-vation well #1	drawdown straight line	9700	1.2×10^{-4}	775	1840	1300
	drawdown type curve	8000	1.7×10^{-4}	780	-	-
Obser-vation well #1	recovery straight line	7300	-	-	-	-
Values used in further calculations		8000	1.7×10^{-4}	780	1800	1300

4" well

$t = 20$ years 10^7 min.

$r = 0.17$ ft.

$s = 170$ ft.

$$u = \frac{2244\, r^2\, s}{T\, t} = \frac{2244 \times 0.0289 \times 1.7 \times 10^{-4}}{8000 \times 107} = 1.38 \times 10^{-13}$$

$W(u) = 29.02$ (from standard tables)

$$\frac{s}{Q} = \frac{114.6\, W(u)}{T} = \frac{1.146 \times 10^2 \times 2.902 \times 10^1}{8 \times 10^3} = 0.410 \text{ ft./gpm.}$$

= drawdown per gpm after 20 years due to the effect of the pumped well alone.

To this has to be added the effect of the two image wells, at distances of respectively 780 feet and 1800 feet from the pumped well (theoretically valid if the pumped well was at the location of observation well #1, but the discrepancy should be small).

1st Image Well

$t = 20$ years 10^7 minutes

$r = 780$ feet

$$u = \frac{2244 r^2\, s}{T\, t} = 2.9 \times 10^{-6} \qquad W(u) = 12.17$$

$$\frac{S}{Q} = \frac{114.6 \times 12.17}{8000} = 0.171 \text{ ft./gpm.}$$

2nd Image Well

$t = 20$ years $= 10^7$ minutes

$r = 1800$ feet

$$u = \frac{2244 \times (1800)^2 \times 1.7 \times 10^{-4}}{8000 \times 10^7} = 1.55 \times 10^{-5}$$

$W(u) = 10.5$

$$\frac{S}{Q} = \frac{114.6 \times 10.5}{8000} = 0.148$$

and $S_{total} = (0.410 + 0.171 + 0.148)\,Q$

$170 = 0.729\,Q$

$Q = 233$ gpm.

Applying a safety factor of 75% gives a safe yield of 0.75 x 233 = 175 gpm.

C. Specific Capacity and Efficiency of Pumped Well

Although the present pumping well only served for the aquifer test and was not intended to be used as a production well, a 3-hour step-drawdown test was conducted in order to determine the efficiency of the present pumping well. Data obtained from the step-drawdown test were plotted (figure 6), and specific capacity figures for a one-hour pumping period were then calculated for the pumping rates used. Theoretical values of specific capacity for the same period of one hour are calculated using the Theis nonequilibrium formula and the aquifer constant.

$r = 0.17$ feet

$t = 60$ minutes

$$u_1 = \frac{2244\, r^2\, s}{T\, t} = 2.3 \times 10^{-3} \qquad W(u)_4 = 17 \text{ and}$$

$$S = \frac{114.6\, Q \,.\, W(u)}{T} \quad . \quad S_1 = 0.244\, Q$$

This is the effect due to the pumping well alone. The effect of the 1st image well is calculated using the same formula but r = 780 feet in this case.

$$u_2 = \frac{2244 \times (780)^2 \times 1.7 \times 10^{-4}}{8000} = 0.51 \qquad W(u_2) = 0.547$$

and $S_2 = 0.008\ Q$.

The effect of the 3rd image well after one hour pumping is negligably small. Therefore, we can write

$$S_{total} = S_1 + S_2 = (0.244 + 0.008)\ Q = 0.252\ Q.$$

From this equation the theoretical specific capacity (= the rate of pumpage which will cause a drawdown of one foot after a pumping period of one hour if the well is 100% efficient) follows:

$$\frac{Q}{S} = \frac{1}{0.252} = 3.97 \text{ gpm./ft.}$$

The efficiency of the well is the ratio of the actual specific capacity to the theoretical specific capacity, multiplied by 100 if expressed in %. A table and plot of the results of the calculations are presented in figure 7. The average efficiency is ± 35%.

This low efficiency is caused by the small open area through which the water can enter the well inducing a high entrance velocity giving rise to turbulent flow through the screen and inside the well. The open area can be increased by

(1) increasing the diameter of the well to 6"

(2) increasing the length of the screen to cover the total thickness of the aquifer (10 feet).

(3) use a screen with larger slot openings if mechanical analysis of the aquifer samples warrant so.

Summary of Pertinent Data

Depth of aquifer at test site :	199 feet
Thickness of aquifer at test site:	11 feet
Width of aquifer (from pump test data) :	± 1300 feet
Transmissibility :	8000 imp. gal. per day per foot
Storage coefficient :	1.7×10^{-4}
Safe yield of aquifer :	175 gpm for 20 years
Efficiency of pumped well (test well #1) :	35%

Comments and Conclusions

The 1962 test drilling program of the town of Stettler revealed the presence of a good gravel aquifer in a buried bedrock channel tributary to the Erskine channel. Mapping of the bedrock topography of the area gives a fairly accurate idea of the course of the channel but further test drilling will be necessary to substantiate or possibly modify the present picture. It should further be underlined that the map depicts the presence of the channel and not of the gravel aquifer, which may come and go and vary in thickness along the course of the channel.

Because of its closer proximity to the towns present pipeline system, the headwaters of the channel (NE corner of Sec. 33, Tp. 38, R. 20, W. 4 M.) are of most interest to the town and it is recommended that future test drilling be concentrated in this area. The seismic shot hole reporting the bedrock elevation at 2466 feet is located approximately 500 feet south of the section corner; the formation log for this hole did not have the superficial deposits differentiated but reported 202 feet of clay, sand and gravel above bedrock.

Some consideration should also be given to the sand and gravel deposits encountered at test holes Nos. 1, 4, and 5 at shallower depth and with thicknesses of 20, 50, and 30 feet, respectively. These sand and gravel deposits are also related to the buried channel and cover a wider area than the basal gravel deposit. Observation well #2, which was put down into this aquifer, had a static water level of 20.5 feet below surface giving an available drawdown of 42 feet. During the 48-hour pumping test no drawdown was observed in this well; therefore, the shallower aquifer is a separate reservoir, which should also be subjected to a pump test in the future.

Altogether, the buried channel deposits located in the 1962 test drilling program contain at least one excellent aquifer, which could very well prove to become the primary source of the Stettler water supply.

Oct, 1962

Appendix A

Test Hole Logs

Test hole # 62-1
Northwest corner of Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: August 29, 1962.

0 - 15	yellow clay, a few pebbles, some coal.
15 - 25	blue clay, some sand.
25 - 28	very fine sand and clay.
28 - 30	gravel
30 - 43	blue clay and very fine sand.
43 - 44	gravel
44 - 45	blue clay
45 - 50	blue clay
50 - 55	sandy blue clay with pebbles
55 - 60	fine sand and gravel
60 - 75	sand aa
75 - 94	blue clay
94 - 105	blue shale, with interbedded very fine bentonitic sandstone.

Test hole # 62-2
Northwest corner of Lsd 15, Sec. 32, T. 38, R. 20, W. 4 Mer.
Drilled: August 29, 1962.

0 - 15	yellow clay, a few pebbles
15 - 30	blue clay, a few pebbles
30 - 45	blue clay, slightly silty, some pebbles
45 - 57	blue clay (sandy)
57 - 60	grey shale
60 - 75	shale, greenish blue, in part silty

Test hole # 62-3
Southeast corner of Lsd 9, Sec. 4, T. 39, R. 20, W. 4 Mer.
Drilled: August 29, 1962.

0 - 12	yellow clay with pebbles
12 - 15	blue clay
15 - 30	blue clay with pebbles
30 - 45	blue clay, slightly sandy
45 - 60	As above, with minor very fine sand and silt
60 - 80	blue clay with pebbles
80 - 90	green hard shale, interbedded with soft brown shale

Test hole # 62-4
Northwest corner of Lsd 15, Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: August 29 and 30, 1962.

0 - 5	yellow clay with very fine sand
5 - 15	yellow clay
15 - 25	yellow clay with pebbles
25 - 30	blue clay, some very fine sand
30 - 40	blue clay
40 - 45	blue clay, thin layers of gravel
45 - 55	blue clay
55 - 60	blue clay (some very fine sand, which is probably caving)
60 - 65	sand and gravel (sample #1)
65 - 70	fine sand (sample #2)
70 - 75	sand (sample #3)
75 - 80	sand (sample #4)
80 - 103	fine sand
103 - 105	medium gravel, coarse sand; clay layer
105 - 110	coarse sand (sample #5)
110 - 120	Interbedded hard clay and medium sand
120 - 142	hard clay
142 - 144	gravel and coarse sand
144 - 193	hard clay
193 - 195	very fine sand
195 - 199	fine sand
199 - 210	gravel, 1/8 - 1/4 inch diameter
210 - 219	some coal, shale
219 - 220	hard layer

Test hole # 62-5
1/3 mile south of Northeast corner of Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: August 30, 1962.

0 - 20	very fine sand and clay
20 - 37	blue clay
37 - 45	gravel, lost circulation
45 - 67	gravel with medium sand
67 - 80	clay
80 - 90	grey shale

Test hole # 62-6
Southeast corner of Sec. 3, T. 39, R. 20, W. 4 Mer.
Drilled: August 31, 1962.

0 - 22	yellow clay
22 - 56	blue clay, some silt and very fine sand
56 - 68	very fine sand
68 - 80	clay
80 - 90	blue grey and grey shale

Test hole # 62-7
Northeast corner of Lsd 8, Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: August 31, 1962.

0 - 12	yellow clay
12 - 26	blue clay
26 - 27	very fine sand
27 - 28	clay
28 - 30	coarse sand and gravel
30 - 35	clay
35 - 36	coarse sand and fine gravel
36 - 40	clay
40 - 45	fine gravel
45 - 72	clay with pebbles
72 - 74	bentonitic shale
74 - 75	sandstone with bentonite

Test hole # 62-8
Northeast corner of Lsd 8, Sec. 3, T. 39, R. 20, W. 4 Mer.
Drilled: August 31, 1962.

0 - 20	yellow clay
20 - 32	blue clay
32 - 39	grey silty shale
39 - 45	blue shale

Test hole # 62-9
Southeast corner of Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: August 31, 1962.

0 - 10	yellow clay
10 - 24	blue clay
24 - 26	very fine sand
26 - 28	blue clay

28 - 30	very fine sand
30 - 45	Interbedded blue clay and very fine sand
45 - 57	blue clay
57 - 60	grey silty shale

Test hole # 62-10
Southwest corner of Lsd 10, of Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: August 31, 1962.

0 - 61	sandy clay
61 - 75	shale

Test hole # 62-11 = Test well # 1
Northwest corner of Lsd 15, Sec. 33, T. 38, R. 20, W. 4 Mer.
Drilled: September 5 and 6, 1962.

0 - 5	yellow sandy clay
5 - 22	brown clay and pebbles
22 - 60	blue clay and pebbles
60 - 70	sand and gravel
70 - 103	sand with thin beds of gravel
103 - 110	gravel with thin beds of clay
110 - 140	blue clay and pebbles
140 - 144	gravel
144 - 193	hard grey clay and pebbles
193 - 198	sand with some gravel
198 - 209	gravel, thin beds of sand and shale; coal boulders
209 - 211	shale, light grey and sandy
	Spoon samples taken from 198-199'9" and from 203-205 feet.

Test hole # 62-12 = Observation well #1 100 feet west of Test well #1
Drilled: September 10, 1962.

0 - 8	sandy brown clay
8 - 22	brown clay with some gravel
22 - 34	blue clay with pebbles
34 - 50	sand and gravel with thin layers of clay
50 - 62	blue clay and pebbles
62 - 80	sand and gravel
80 - 108	coarse sand and fine gravel
108 - 110	clay with some gravel
110 - 138	blue clay with pebbles
138 - 144	gravel
144 - 193	hard grey clay
193 - 196	sand
196 - 208	gravel. Lost circulation

Test hole # 62-13 = Observation well #2
500 feet west of Test well # 62-1
Drilled: September 15, 1962.

0 - 18	brown sandy clay
18 - 63	blue clay and rocks
63 - 100	sand and gravel

Appendix B

Completion and Development Data

Test Well #1 (Test hole # 62-11)

Drilled: September 5 to 6, 1962.

Screen: 5 feet of 4 inch #25 slot Everdur sand screen from 203-208 feet.

Casing: 204 feet of 4 1/2 O.D. inserted joint casing. Casing left approximately 1 foot above ground level.

Development: September 6, 1962. Started developing by backwashing with pump from drill.

September 7, 1962. Rained very hard, for 1 1/2 hrs only.

September 8, 1962. Developed well by pumping and backwashing, then used air compressor. Pumped with air at 60-70 gpm.

Observation Well # 1 (Test hole # 62-12)

Drilled: September 10, 1962.

Screen and Casing: 201 feet of 1 1/4 I.D. galvanized pipe with sand point attached, pipe approximately 6 inches above ground level.

Development: By backwashing with mud pump, then pumped test well #1 to see if observation well would respond. Drawdown was 1 foot while test well drawdown was 8 feet after 1 hr. pumping at 20 gpm.

Observation Well # 2 (Test hole # 62 -13)

Drilled: September 15, 1962

Sand point: 30" of No. 15 slot 2" O.D.

Casing: 84.5 feet of 1 1/4 I.D. galvanized pipe. Pipe left approximately 6" above ground level.

Appendix C

Pump Test Data

(1) 48-hour constant rate test:

Well No. :	Test well # 1 (pumped well)
Time Test started :	Nov. 2, 1962, at 9:45 a.m.
Time Test stopped :	Nov. 4, 1962, at 9:45 a.m.
Static level before test:	22.50 ft. below top of casing
Rate:	70 Imp. gallons/minute

Date	Hour	Time since pumping started in min.	Drawdown in feet	Date	Hour	Time since pumping started in min.	Drawdown in feet
Nov. 2/62	9:45 a.m.	0	0		0:45 p.m.	180	43.04
		1/2	34.40			210	43.80
		1	34.00			240	44.16
		2	36.95			300	45.12
		3	36.90			360	45.24
		4	37.65			420	46.30
	9:50 a.m.	5	37.90			480	46.50
		6	38.13		7:45 p.m.	600	46.87
		7	38.17			720	47.50
		8	38.35	Nov. 2	11:45 p.m.	840	47.90
		9	38.60	Nov. 3	3:45 a.m.	1080	48.50
	9:55 a.m.	10	38.65			1320	49.10
		12	39.45		11:45 a.m.	1560	49.71
	10:00 a.m.	15	39.10	Nov. 3	3:45 p.m.	1800	49.58
		20	39.90		7:45 p.m.	2040	50.75
		25	39.90		11:45 p.m.	2280	51.30
		30	40.26	Nov. 4	3:45 a.m.	2520	51.70
		40	40.42		7:45 a.m.	2760	52.30
		50	41.11		9:45 a.m.	2880	52.30
		60	41.45		10:00 a.m.	2895	51.90
	11:00 a.m.	75	41.72				
		90	42.20				
		105	42.67				
		120	42.89				
		150	43.34				

Notes: (1) Rate varied in the first 2 min. of the test.
(2) Rate varied from 11:00 p.m. Nov. 3, to 6:00 a.m. Nov. 4 due to temperature changes.
(3) Measurements taken with electric tape.

48 hour constant rate test

Well No.: Observation well #1

Static level: 19.83 feet below top of casing

Distance from pumped well: 100 ft.

Date	Hour	Time since pumping started in minutes	Draw-down in feet	Date	Hour	Time since pumping started in minutes	Draw-down in feet
Nov. 2, 1962	9:45 AM	0	0	Nov. 2, 1962	10:45 AM	120	5.77
		1/2	0.53			150	6.20
		1	0.69			180	6.53
		2	1.19			200	6.80
		3	1.57			230	7.10
		4	1.75			270	7.46
		5	1.93			300	7.74
		6	2.07			360	8.20
		7	2.15			420	8.65
		8	2.33			480	8.96
		9	2.45			540	9.20
		10	2.55			600	9.50
		12-1/2	2.65			660	9.70
	10:00 AM	15	2.93		9:45 PM	720	10.00
		20	3.25		10:45 PM	780	10.20
		25	3.50		11:45 PM	840	10.30
		30	3.69	Nov. 3,			
		35	3.87	1962	0:45 AM	900	10.50
		40	4.05			1000	10.70
		45	4.19			1100	10.90
		50	4.35		5:45 AM	1200	11.10
	10:45 AM	60	4.63		10:45 AM	1500	11.20
		70	4.85			1700	11.40
		80	5.05		3:45 PM	1800	11.50
		90	5.25			2000	11.70
		100	5.43			2200	11.90
				Nov. 4, 1962	9:45 AM	2880	12.27

Note: Water levels measured with Stevens recorder

Well No.: Observation well #2

Static level: 20.95 feet below top of casing

Distance from pumped well: 500 ft.

The water level in this well did not change during the 48 hour pump test

Recovery

1. Pumped well

Date	Hour	Time since pumping began / Time since pumping stopped $= \frac{t}{t'}$	Residual Drawdown in feet
Nov. 4, 1962	10:00 AM		51.90
	10:01 AM	2890	11.85
	10:02 AM	1446	11.84
	10:03 AM	964	11.50
	10:04 AM	723	11.30
	10:05 AM	575	11.13
	10:06 AM	483	11.02
	10:07 AM	414	10.96
	10:08 AM	382	10.82
	10:09 AM	322	10.74
	10:10 AM	290	10.66
	10:12 AM	242	10.35
	10:15 AM	194	10.17
	10:20	145	9.82
	10:25	116	9.55
	10:30	97	9.45
	10:40	73	9.00
	10:50	58	8.75
	11:00 AM	49	8.50
	11:15	39.6	8.20
	11:30	33.1	7.88
	11:45	28.5	7.42
	12:00 Noon	25.1	7.08
	12:30 PM	20.2	6.85
	1:00	17.0	6.66
	1:30	14.8	6.32
	2:00	13.0	6.05
	3:00	10.6	5.60
	4:00	9.0	5.20

Recovery of Observation Well #1 Nov. 4, 1962

Hour	Time since pumping stopped = t'	$\frac{t}{t'}$	Residual Drawdown
10:00 AM	0		13.22
10:00 1/2	1/2	5780	12.17
10:01 AM	1	2891	12.07
	2	1446	11.77
	2.5	1194	11.67
	3	964	11.47
	4	724	11.39
	5	579	11.33
	7-1/2	440	10.99
	10	290	10.71
	12-1/2	232	10.49
10:15 AM	15	195	10.29
	17-1/2	166	10.13
	20	145	9.99
	25	113	9.75
10:30 AM	30	97	9.55
	35	83	9.37
	40	73	9.24
	45	65	9.09
	50	59	8.96
11:00 AM	60	49	8.73
	70	42	8.50
	80	36	8.30
	90	33	8.13
	100	30	7.95
12:00 Noon	120	25	7.67
	140	21.7	7.39
	160	19	7.17
1:00 PM	180	17	7.05
	200	15.4	6.84
2:00 PM	240	13.0	6.42
3:00 PM	300	10.6	5.95
4:00 PM	360	9.0	5.55
4:15 PM	375	8.7	5.45

Step Drawdown Test   Nov. 4, 1962

Static Level: 22:50 ft.: Level prior to test: 27.60 ft. (5.10 ft. drawdown from previous 48 hour test)

Pumped Well				Pumped Well			
Time in hr. and min.	Time since pumping began	Draw-down	Discharge	Time in hr. and min.	Time since pumping began	Draw-down	Discharge
4:31 PM	1	30.50	46 gpm	5:40 PM	70	41.65	61 gpm
4:31 PM	2	31.30	"		72	41.75	"
4:32 PM	3	31.10	"		75	42.05	"
	4	31.35	"		80	42.15	"
	5	31.35	"		85	42.10	"
	6	31.40	"	6:00 PM	90	42.30	"
	7	32.30	"		95	42.20	"
	8	32.00	"		100	42.40	"
	9	32.25	"		110	42.80	"
4:40 PM	10	32.40	"	6:30 PM	120	42.40	"
	12	32.70	"		121	55.25	82 gpm
	15	32.65	"		122	56.15	
	20	33.30	"		123	56.05	
	25	33.54	"		124	56.45	
	30	33.73	"		125	56.45	
	35	33.19	"		126	57.04	
	40	33.89	"		127	57.07	
	50	33.84	"		129	57.14	
5:30 PM	60	33.65	"	6:40 PM	130	57.23	
5:31 PM	61	40.60	61 gpm		132	57.49	
	62	41.40	"		135	57.04	
	63	41.70	"		140	57.33	
	64	41.15	"		145	57.70	
	65	41.40	"		150	57.37	
	66	41.90	"		155	57.49	
	67	41.35	"	7:00 PM	160	57.42	
	68	41.65	"		170	57.60	
	69	41.55	"	7:30 PM	180	57.60	

Stettler Observation well no 2 $r_p = 100$ ft.

Constant Discharge 48-hr pumptest

November 2, 3 & 4, 1962.

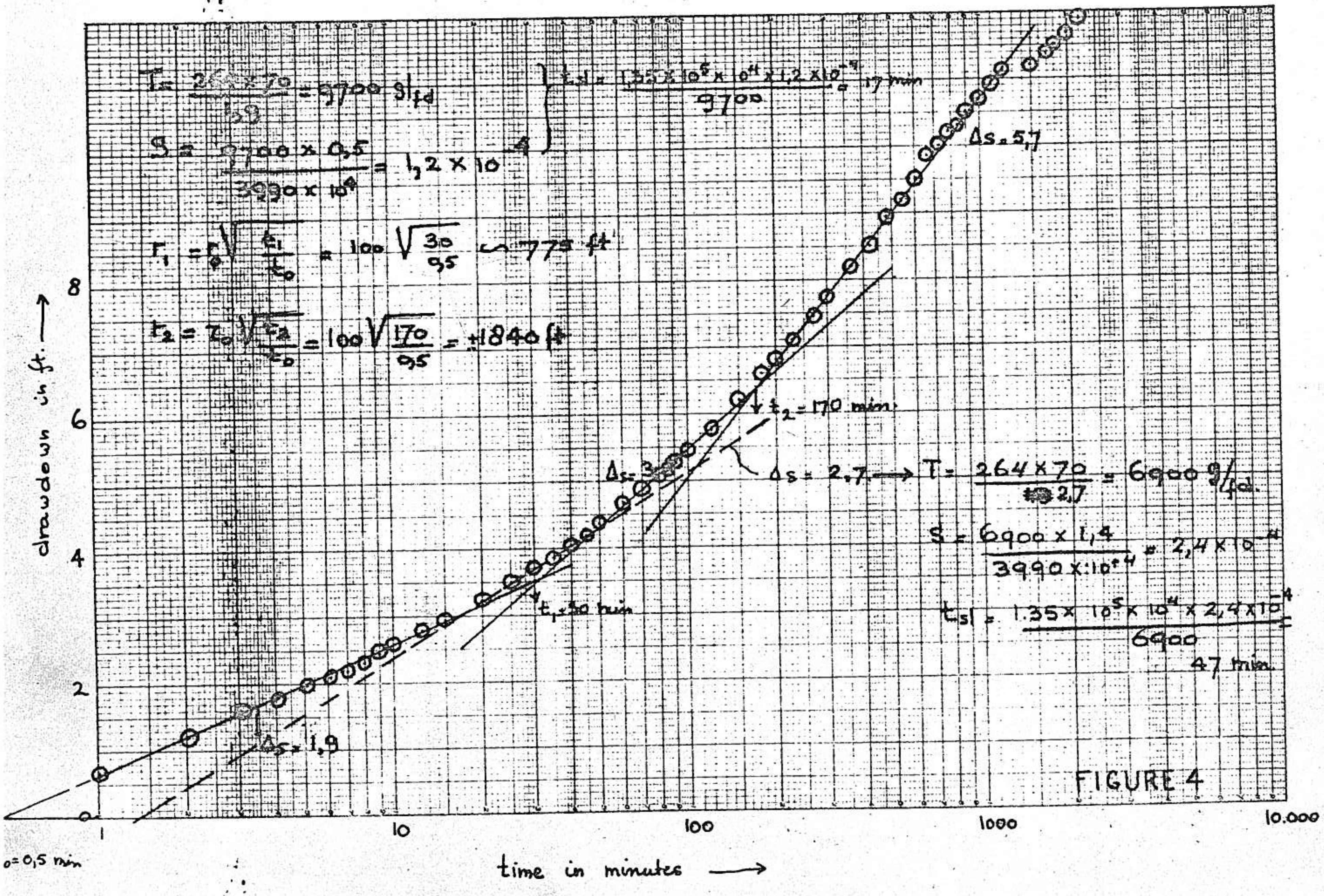
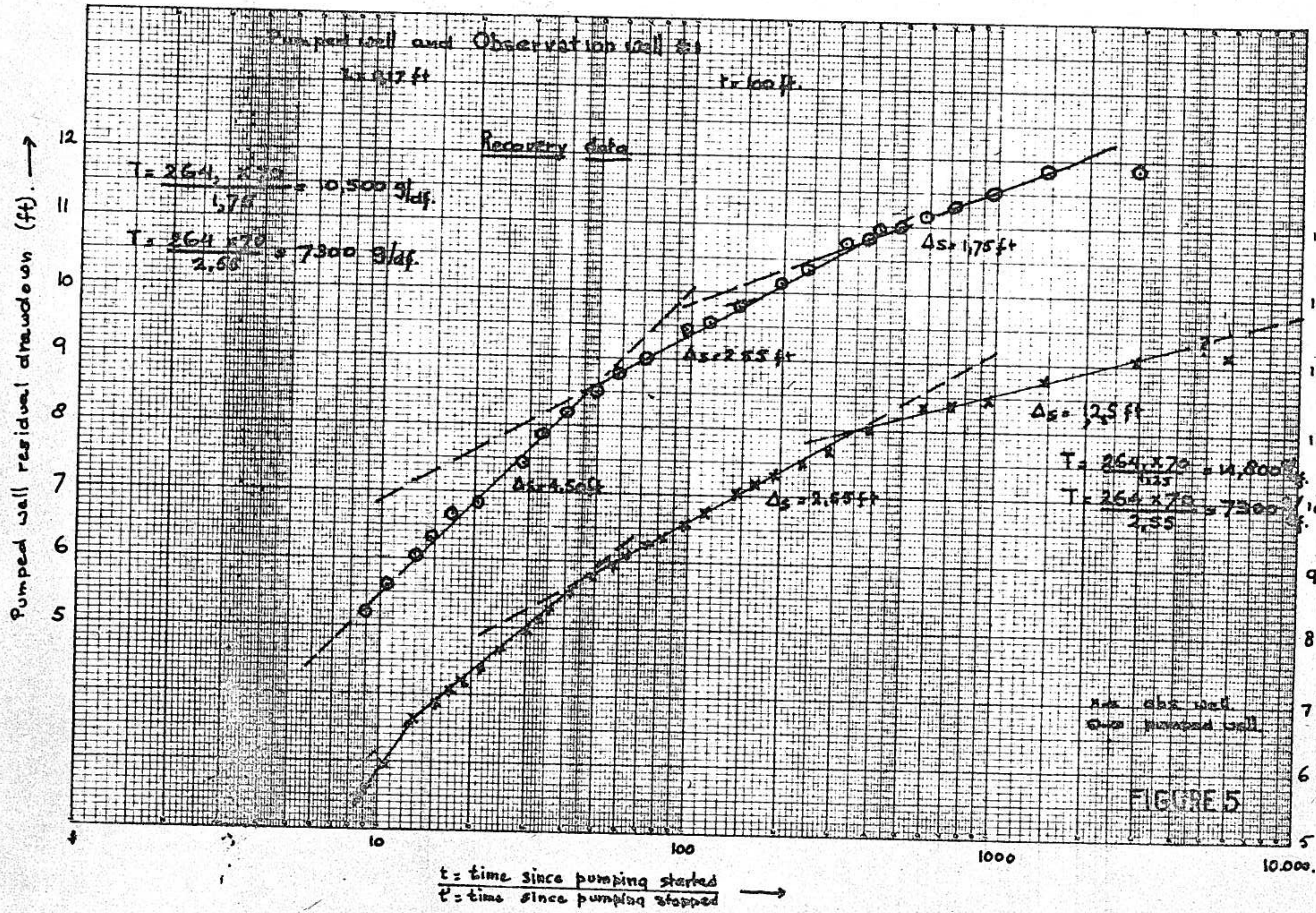
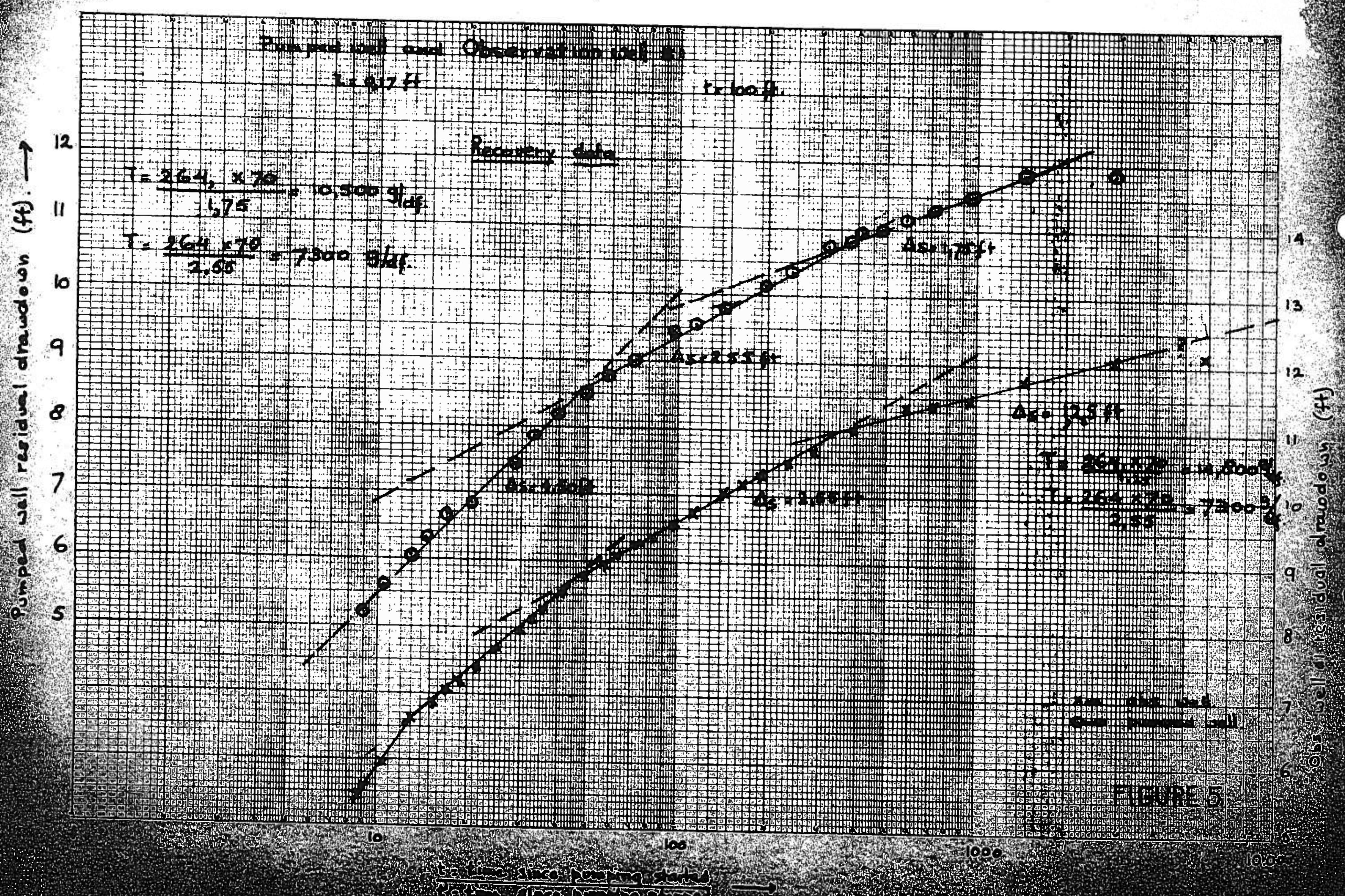


FIGURE 4



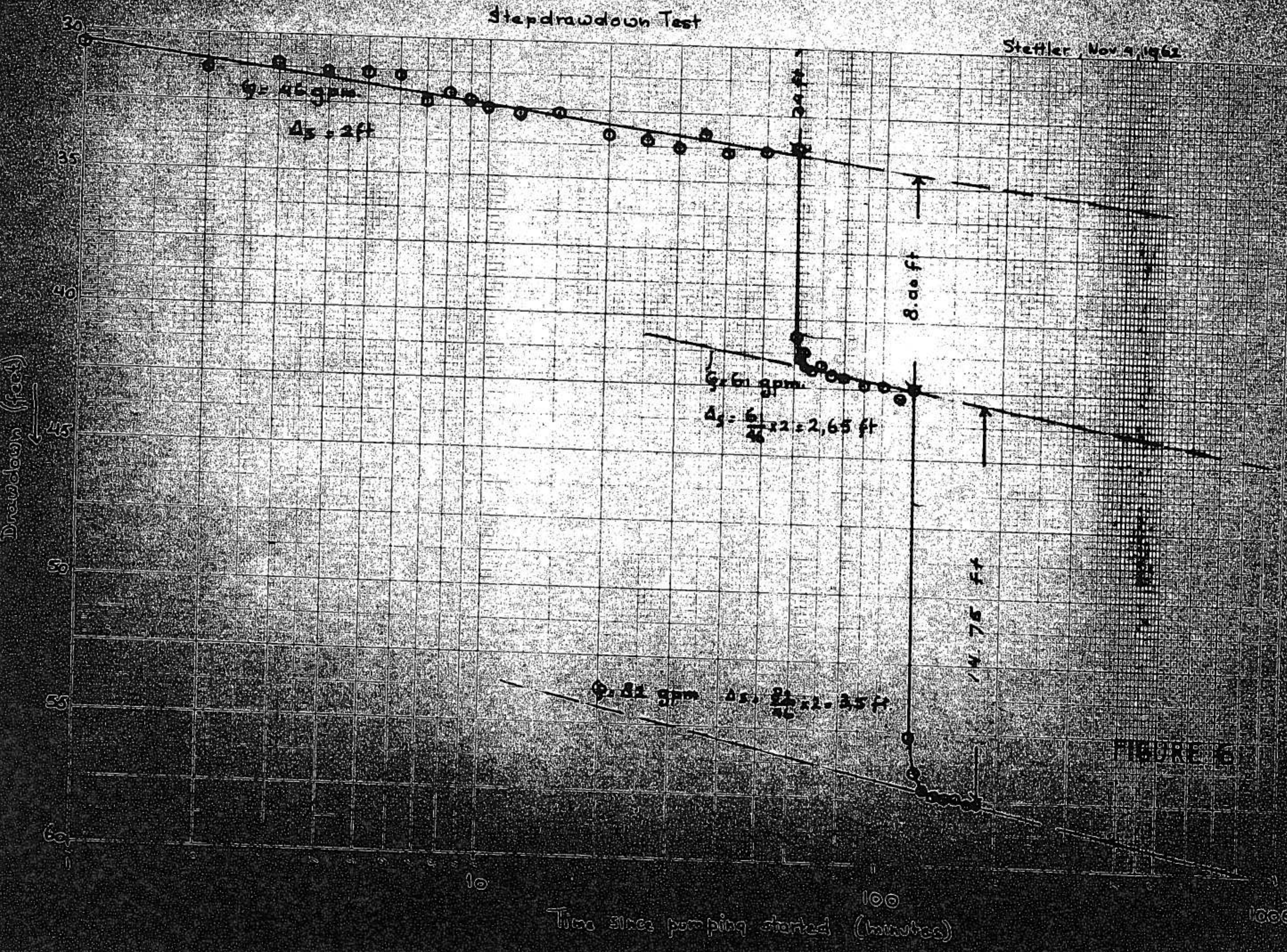
Pumped well and Observation well #1
r = 0.17 ft
r = 100 ft.
Recovery data
T = 264 x 70 / 1.75 = 10,500 g/df.
T = 264 x 70 / 2.55 = 7300 g/df.
Δs = 1.75 ft
Δs = 2.55 ft
Δs = 4.50 ft
Δs = 2.55 ft
Δs = 1.25 ft
T = 264 x 70 / 1.25 = 14,800 g/df.
T = 264 x 70 / 2.55 = 7300 g/df.
x-x obs. well
o-o pumped well
Pumped well residual drawdown (ft).
Obs. well #1 residual drawdown (ft)
t = time since pumping started
t' = time since pumping stopped
10
100
1000
10.000

FIGURE 5



Recovery data
T = 264 × 70 / 2.55 = 7300 g/df
Pumped well residual drawdown (ft)
Obs. well residual drawdown (ft)
10
100
1000

FIGURE 5



Stepdrawdown Test
Stettler, Nov 9, 1962
Q = 46 gpm
Δs = 2 ft
Q = 61 gpm
Δs = 61/46 x 2 = 2.65 ft
Q = 82 gpm
Δs = 82/46 x 2 = 3.5 ft
8.00 ft
14.75 ft
Drawdown (feet)
Time since pumping started (minutes)
30
35
40
45
50
55
60
1
10
100
1000

FIGURE 6

Nov 4 /62

Nov. 4, 1962 — Revised analysis of step-drawdown data demonstrating laminar flow.

T = 60 minutes

Δs_1 = 33.8 — ΔQ_1 = 46 gpm

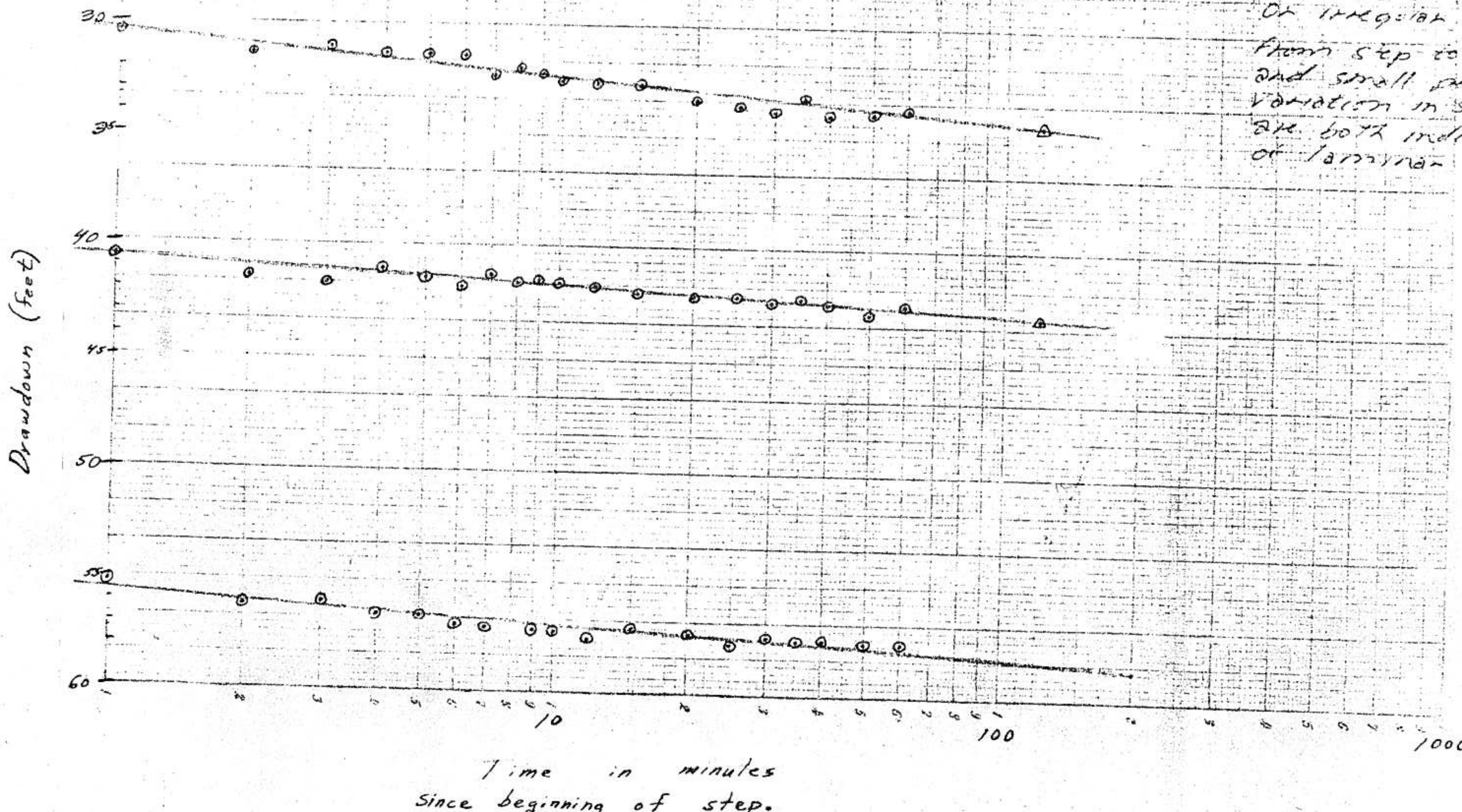
Δs_2 = 42.6 - 34.3
= 8.3 feet — ΔQ_2 = 15 gpm

Δs_3 = 57.9 - 42.8
= 15.1 feet — ΔQ_3 = 21 gpm

s_w	Q_n	s_w/Q_n
33.8	46	.735
42.1	61	.690
57.2	82	.697

av. = .707 ± .02[illegible]

Decreasing s_w/Q_n or irregular [illegible] from step to st[ep] and small [illegible] variation in s_w/Q_n are both indicat[ive] of laminar flo[w].



Pumping Rate in g p m	Theoretical Spec. capacity = T gpm/ft	Actual Spec. Capacity = A gpm/ft.	% efficiency = A×100 / T
46	3,97	1,35	34%
61	3,97	1,45	36,5%
82	3,97	1,45	36,5%

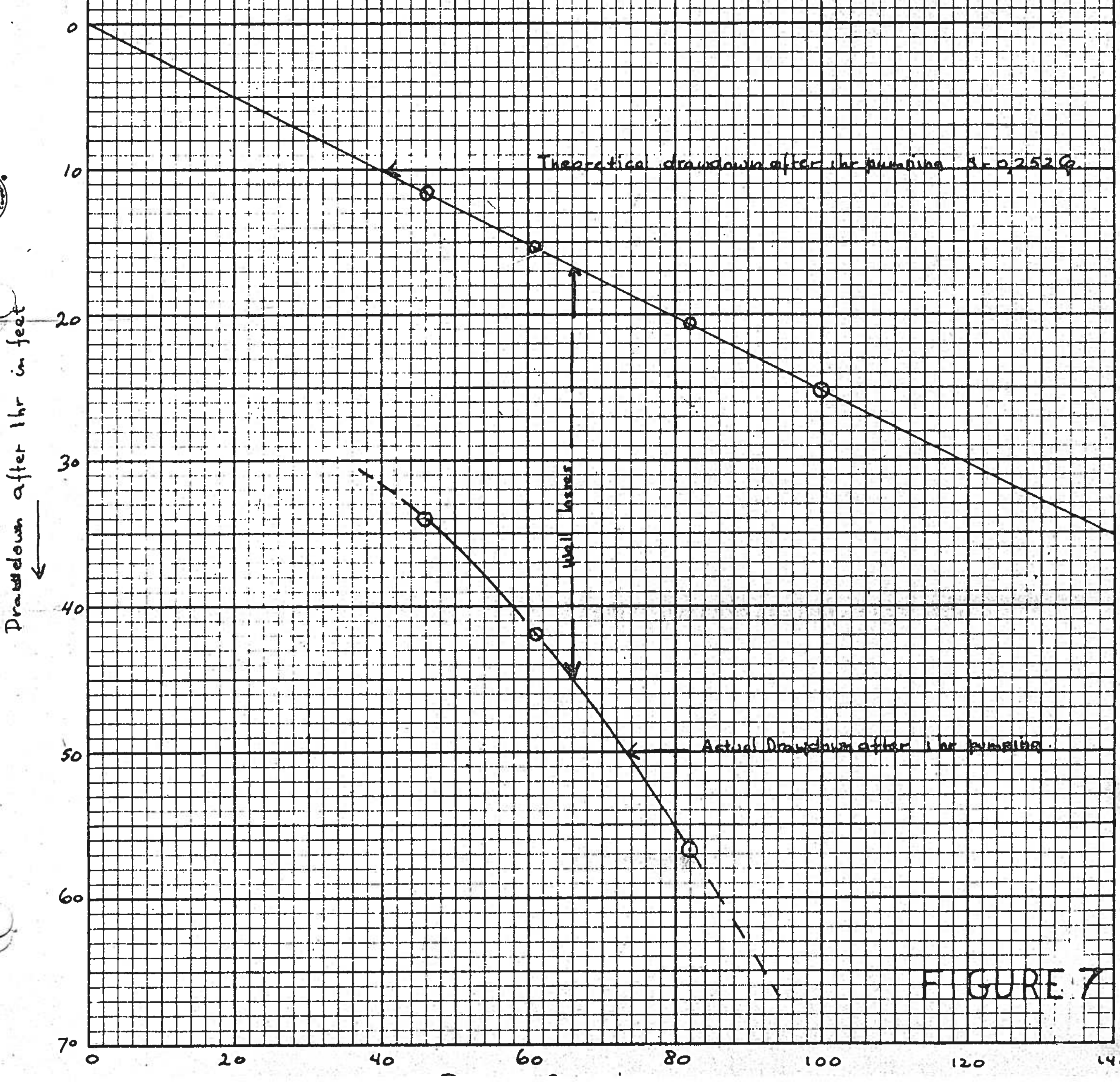


FIGURE 7

[illegible] 1962

15-33-38-20-ww

Well Location: Step-drawdown test [illegible]

Status: Pumped well

[illegible]r:

[illegible] pumping level. 22.50

Pumping Test:

Conducted by:

Date: Nov 4 1962.

Page: 1.

Date	Time	t minutes	r^2/t / $r^2/(1/t)$	Static water level	Depth to water	+3 ft Draw-down	Volume	Q GPM	Remarks
	16.30D	0.	~~25.60~~	~~22.50~~	~~27.60~~	2.10.	46	46	[illegible] completely recovered
		1		22.50	53.00	27.50			
		2			53.80	28.30			
		3			53.60	28.6.			
		4			53.85	28.35			
		5			53.85.	28.35			
		6			53.90	28.40			
		7			54.80	29.30			
		8			54.50	29.00			
		9			54.75	29.25.			
		10			54.90	29.40.			
		12			55.20	29.70.			
		15			55.15	29.65.			
		20			55.80	30.30.			
		25.			56.04	30.54.			
		30.			56.25	30.73			
		35			55.69.	30.10			
		40			55.39	29.80			
		~~45~~ 50			56.34	30.84			
		60			56.15	30.65		46	
		61			63.10	37.60		61 gpm.	
		62			63.90	38.40			
		63			64.20	38.70			
		64.			63.65	38.15			
		65.			63.90.	38.40			
		66.			64.40	38.90			
		67.			63.85	38.35			
		68			64.15	38.65			
		69			64.05	38.55			
		70			64.15	38.65			

Well Location ______________ Pumping Test: ______________ Date: ______________

Status: ______________

r: ______________ Conducted by: ______________ Page: 2

Date	Time	t minutes	r^2/t / $r^2/1/t$	Static water level	Depth to water	Draw-down	Volume	Q GPM	Remarks
17.42		72		25.50	64.25	38.75			
		75			64.55	39.05			
		80			64.65	39.15			
		85			64.60	39.10			
		90			64.80	39.30			
		95			64.70	39.20			
		100			64.90	39.40			
		110			65.30	39.80			
		120			64.90	39.40			
		121			77.75	52.25	→ @ 52.25	82 gpm	
		122			78.65	53.15			
		123			78.55	53.05			
		124			78.95	53.45			
		125			78.95	53.45			
		126			79.54	54.04			
		127			79.507	54.27			
		129			79.64	54.14			
		130			79.73	54.23			
		132			79.99	54.49			
		135			79.54	54.04			
		140			79.83	54.33			
		145			79.90	54.40			
		150			79.87	54.37			
		155			79.99	54.49			
		160			79.92	54.42			
		170 ~~167~~			80.10	54.60			
		180			80.10	54.60			
		1							

STETTLER REPORT

GROUNDWATER GEOLOGY AND HYDROLOGY

by

W. A. Meneley

WATER SUPPLY

TOWN OF STETTLER

During 1957 and 1958 the Research Council of Alberta undertook a groundwater survey of the Stettler area to investigate the distribution and characteristics of aquifers within the area. Several problems were encountered during the course of the investigation, the most important of these was the shortage of water in Stettler.

The Town of Stettler has relied upon wells as a source of water since the distribution system was first installed. There are no nearby sources of surface water, and in the past an adequate supply of water was obtained at low cost from a few wells located in the Town. The increased demand for water caused by the rapid increase in population since 1949, and increasing per capita consumption, severly overburdened the capacity of the existing supply wells. Despite the addition of several new wells to the supply system during the period from 1949 to 1958, the quantity of water available from the present total of 10 producing wells in the well field is insufficient to supply the peak-load demand to the distribution system. The problem now facing the Town is where to obtain the additional amount of water to satisfy both the immediate demand and to provide for increased requirements in the future.

This report summarizes the information obtained during the investigation and suggests methods of applying this information to the problem of locating and developing new sources of water supply for Stettler.

There are three possible sources of water to meet the anticipated demand. They are:

1) to extend the existing well field outside the Town limits, to further exploit the bedrock aquifer presently being used;

2) to locate and develop new aquifers outside of Stettler;

3) to obtain water from a surface source such as Buffalo Lake or the Red Deer River.

Each alternative possesses definite advantages and disadvantages, but in the final analysis the best source is the one which will provide the required amount of water for a minimum cost. The evaluation of a source of surface water is beyond the scope of this report and will not be dealt with further.

No attempt was made to evaluate the potential productivity of every aquifer in the area; instead, the general habitat of groundwater within the area was studied. More detailed studies were carried out on two typical aquifers in the area, one a sand and gravel aquifer in a buried channel, and the other an aquifer in the Edmonton formation at Stettler.

All water wells in the area obtain water either from sand and gravel deposits which occur within or at the base of the glacial drift, or from sandstone in the underlying bedrock, the Upper Cretaceous Edmonton formation. No wells in the area obtain water from formations underlying the Edmonton formation. The glacial drift was deposited on the eroded surface of the Edmonton formation by glacial action. Sand bodies occurring within the glacial deposits generally have a limited areal extent, and consequently high capacity wells can rarely be developed in deposits of this type. Sand and gravel deposits which occur in buried channels incised into the bedrock tend to be continuous over larger areas, and thus constitute much better potential aquifers. One such buried channel was discovered during this study. It extends eastward from Buffalo Lake through township 40, ranges 18, 19, and 20, W. 4th meridian. A total of 10 test holes were drilled by the Research Council of Alberta to prove the existence of this channel, and to evaluate its potential as an aquifer. Although this phase of the study is not yet complete, it appears that much more test drilling and development work is required before the potential yield of this aquifer can be assessed.

The regional map of the piezometric surface (the elevation to which water rises in a well) of wells completed in the bedrock shows that the Edmonton formation behaves hydrologically as a single aquifer. This aquifer is recharged from the upland south of the Stettler area. The piezometric surface slopes downward toward the north, indicating that the regional direction of groundwater movement is northward. The aquifer discharges into the buried channel through Buffalo Lake. The piezometric contours also indicate that the aquifer discharges into Red Willow Creek, and that the well field in Stettler is also an area of discharge.

Although the Edmonton formation behaves hydrologically as a unit, geological conditions control to a great extent the specific yield of individual wells tapping the aquifer. The upper part of the Edmonton formation is more sandy and generally speaking wells tapping the upper part of the formation have a higher specific yeild than those tapping the lower Edmonton formation. In addition, there are lateral variations in the amount and coarseness of sandstone present in the Edmonton formation. The Edmonton formation dips westward at 10 - 50 feet per mile, and the bedrock surface slopes downward toward the north at about 25 feet per mile. Thus erosion has removed the most productive part of the Edmonton formation to the east and north of Stettler.

Detailed study of the Edmonton formation aquifer within Stettler has disclosed several problems that must be considered in any further development of the Stettler well field. Unfortunately, no records were kept on water wells and test holes drilled by the Town prior to 1957. However, since that time the Town has drilled four test holes, three of which have been completed as water wells. Cutting samples were collected from all test holes during drilling and detailed geologic logs prepared. Pumping tests have been run on all test holes completed as water wells. Well #11, drilled in 1957 in the southwest corner of town, was initially drilled to a depth of 300 feet. No water-bearing horizons were encountered between 150 and 300 feet so the well was plutted back and completed at a total depth of 157 feet. This well is now capable of producing about 55,000 gallons per day, on continuous production. No further exploration was carried out in 1957. In August, 1958, a test hole (Stettler 58-1) was drilled in the northeast corner of town. This hole was abandoned at a total depth of 260 feet. This well produced about 1 gallon/min. on a bailer test. Another test hole was drilled beside the No. 1 reservoir, and completed as water well No. 1-A at a depth of 160 feet. This well was intended to provide auxiliary pumping capacity to supply the No. 1 reservoir. It is presently capable of producing about 7,000 gallons/day. A third test hole located beside the new skating rink was completed as Well #12, at a total depth of 140 feet. This well is presently capable of producing about 52,000 gallons per day.

In all testing to date, no economic amount of water has been obtained at depths greater than 150 feet. A well drilled in the Red Willow district encountered salt water and gas at an elevation of approximately 2,200 feet. Gas has been reported at an elevation of about 2,400 feet in a water well drilled in Stettler. It appears that there is little chance of finding potable water at elevations lower than 2,400 feet (i.e. at depths greater than 300 feet) in the immediate vicinity of Stettler.

Study of the cutting samples obtained from the four test holes shows there is a marked decrease in the amount and coarseness of sandstone encountered in the test holes located east of Main St., compared to Wells No. 11 and No. 12, located west of Main St. Pumping tests also show that the specific yield of Well 1-A is much lower than Well #11. A short pumping test run on Well No. 7, and a bailer test of the well at the Stettler Chronic Hospital, indicate that the specific yield of wells also decreases toward the north away from Wells No. 11 and No. 12.

Several pumping tests have been conducted on Wells No. 11 and No. 12, to determine the transmissibility and storage coefficient. If these aquifer coefficients are known it should be possible to predict the capacity and optimum spacing of wells tapping the aquifer. It was not possible to obtain accurate values for the aquifer coefficients from any of the pumping tests conducted because of erratic influence of other pumping wells, and because there were too few properly located observation wells. The pumping tests do indicate that the hydrology of the aquifer is complex and will require considerably more detailed study before accurate predictions are possible.

The most important general conclusion based upon the pumping tests conducted, and on well production records kept by the town, is that the wells presently pumping in the Stettler well field are producing nearly all the water that the formation is capable of yielding from the area now developed. This means that if any new wells are located within the present town limits, no great increase in the over-all pumping capacity of the well field should be anticipated since any increase in production from any new wells will be offset by a corresponding decrease in production of pre-existing wells adjacent to the new wells.

Of the two aquifers studied in this area, the Edmonton formation aquifer in the vicinity of Stettler offers the better prospects for immediate development. The feasibility of extending the existing well field can be more cheaply investigated, and there is a reasonable expectation that additional supplies of groundwater can be obtained from this source. Existing information indicates that the most favorable area for exploration lies to the south and west of Stettler, and further, very careful test drilling will be necessary so that new production wells may be located so as to obtain maximum production with a minimum of interference between wells.

I would definitely recommend a comprehensive testing program to be carried out before any new production wells are completed. The objectives of this testing program should be:

(i) to determine the areal extent and lithology of the aquifer

(ii) to determine the yield of individual wells at different locations in the aquifer

(iii) to determine the aquifer coefficients, so that the behavior of wells in the proposed well field, and the behavior of the well field as a unit, may be predicted with reasonable accuracy

(iv) to find the best locations for new production wells and to calculate the optimum well spacing

The following is an outline of a typical test-drilling program.

(i) Drill 4 1/2 inch diameter hole to bedrock and set 4 1/2 inch casing, either driven or cemented a few feet into bedrock. Drill inside the surface casing to a total depth of 150 feet or to a bottom elevation of 2,500 feet, whichever is deeper.

(ii) Catch and save cutting samples at 5-foot intervals and at any marked change in lithology. A drilling rate log should be kept by the driller. If drilling is done by a rotary rig it would be advantageous to have a resistivity log of each hole. Records should be kept of static water level in the hole during drilling, any zones where there is a loss of drilling fluid, etc.

(iii) Bail test: bailing should be carried out for a minimum of one hour, at a constant rate. If drilled by rotary methods, the bailing test should be rotary methods, the bailing test should be started after all drilling fluid has been circulated or bailed from the hole,
A complete record must be kept of the initial water level in the test hole, the rate of bailing, and the volume of the bailer. After the bailing test is complete, water-level measurements should be taken at intervals until the water rises to its original level.

(iv) Cap the test hole with a removable cap, so that periodic measurements of fluid level can be made.

The locations of six proposed test holes are shown on the enclosed sketch map. On the basis of information obtained from these test holes it should be possible to decide the most favorable direction for immediate expansion. The next step is to drill three more test holes located less than 500 feet apart so that a proper pumping test may be conducted. The group of wells for the pumping test should be located where the aquifer is well developed, and should be at least 1/2 mile from Wells No. 11 and No. 12. Complete pumping tests should be run on one or more of the test holes in the group described above. The other test holes are used as observation wells. A portable pump, preferably a jet pump, or an air-lift pump should be used. It is best to use a pump which is flexible, since it is difficult to drill a small diameter hole which is straight and plumb. It may prove necessary to pump test several test holes to evaluate the hydrologic characteristics of the aquifer.

The optimum well locations and spacing are then decided from the information obtained and the cost to obtain a given quantity of water can then be calculated.

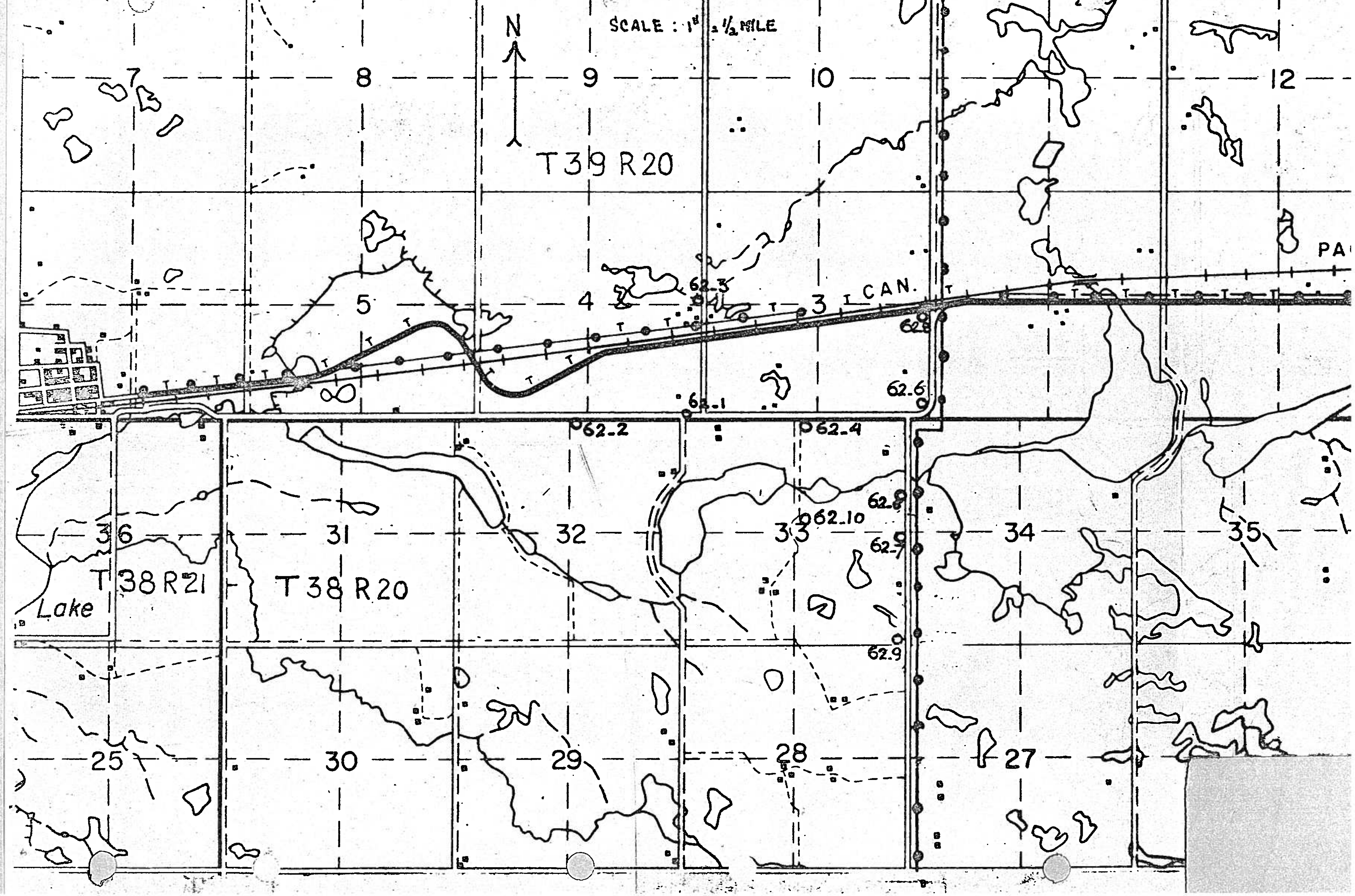
If the cost estimate shows that the proposed extension is feasible, then the required number of production wells can then be drilled.

The program of test drilling outlined above should provide sufficient information for future planning. The primary advantage of such a program is that information can be obtained at relatively low cost, before expensive production wells and a gathering system are installed. Testing should also aid in proper location of production wells and the gathering system to conform with future patterns of residential expansion.

W. A. Meneley,
Research Council of Alberta.

February 13, 1959.

FIG. 1 . LOCATION OF TEST HOLES



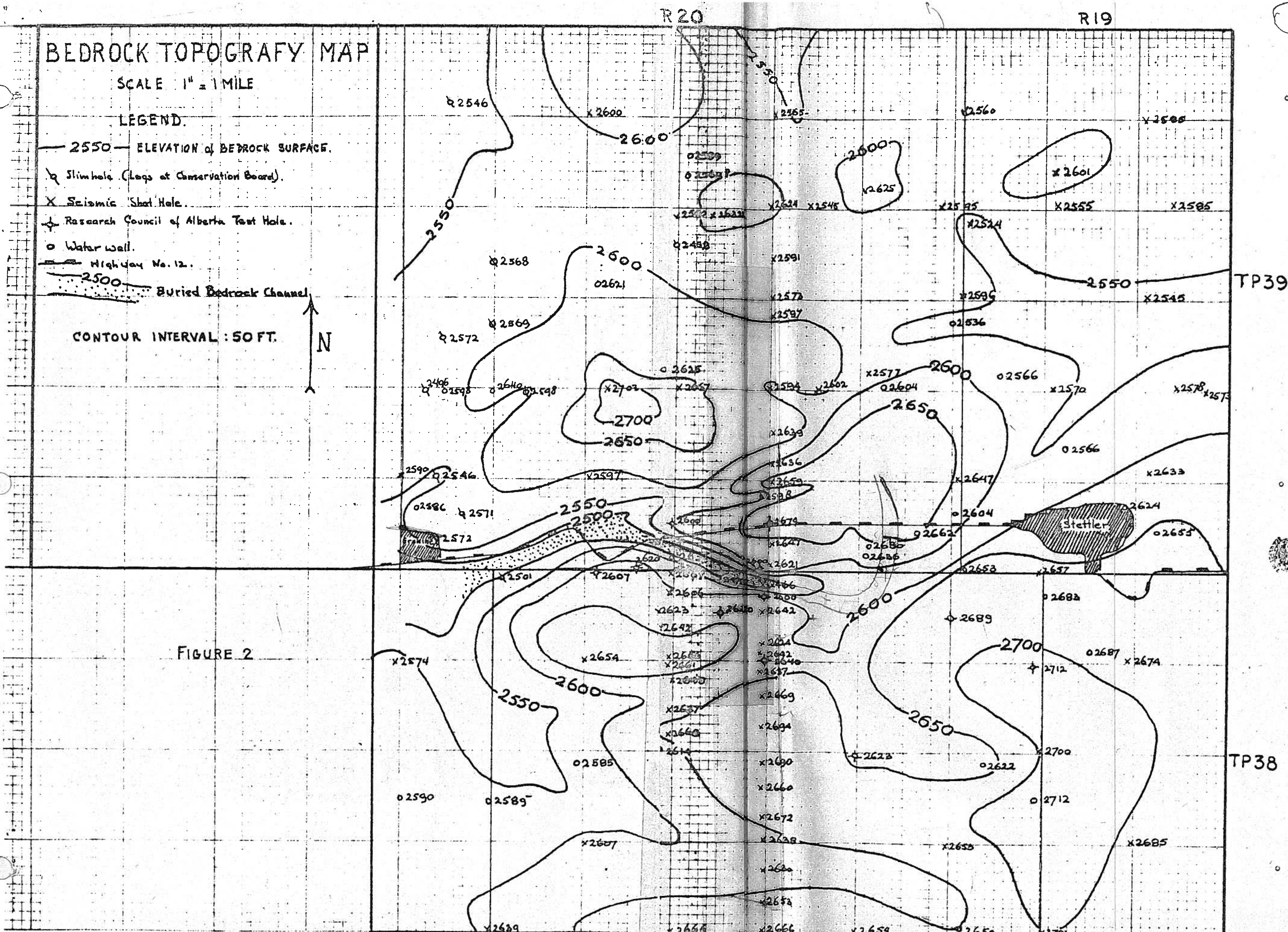
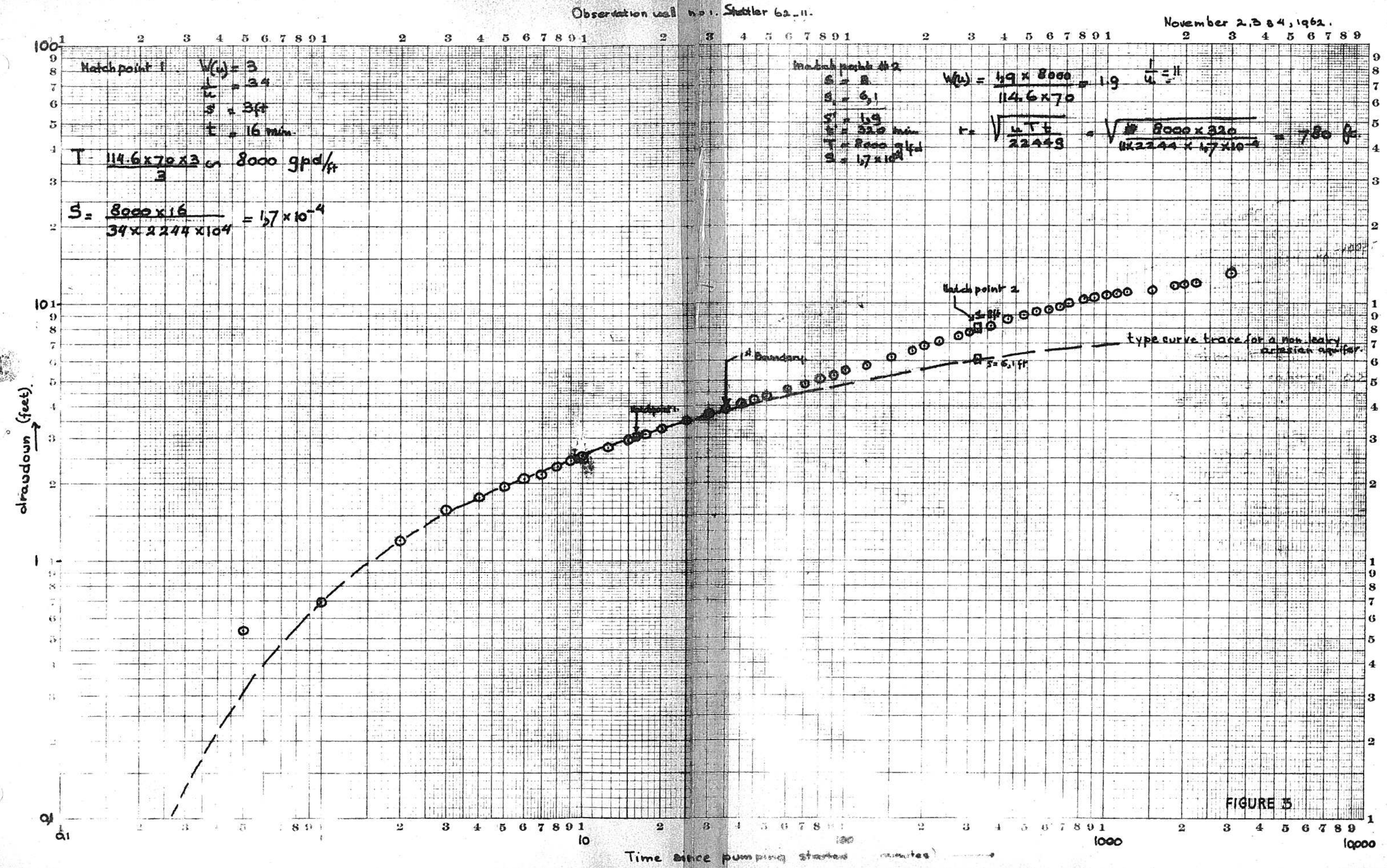

R20
R19
BEDROCK TOPOGRAFY MAP
SCALE 1" = 1 MILE
LEGEND.
2550 — ELEVATION of BEDROCK SURFACE.
Slimhole (Logs at Conservation Board).
X Seismic Shot Hole.
Research Council of Alberta Test Hole.
o Water well.
Highway No. 12.
2500 Buried Bedrock Channel
CONTOUR INTERVAL : 50 FT.
N
TP39
TP38
Stettler

FIGURE 2



Observation well no. 1. Stettler 62-11.
November 2, 3 & 4, 1962.
Matchpoint 1
W(u) = 3
1/u = 34
s = 3 ft
t = 16 min.
T = 114.6 x 70 x 3 / 3 = 8000 gpd/ft
S = 8000 x 16 / 34 x 2244 x 104 = 1.7 x 10^-4
Match point #2
W(u) = 1.9 x 8000 / 114.6 x 70 = 1.9
1/u = 11
s' = 1.9
t = 320 min
T = 8000 g/fd
S = 1.7 x 10^-4
r = √(u T t / 2244 S) = √(8000 x 320 / 11 x 2244 x 1.7 x 10^-4) = 780 ft.
Match point 2
s = 8 ft
s = 6.1 ft
Boundary
Matchpoint
type curve trace for a non leaky artesian aquifer.
drawdown (feet)
Time since pumping started (minutes)
FIGURE 3